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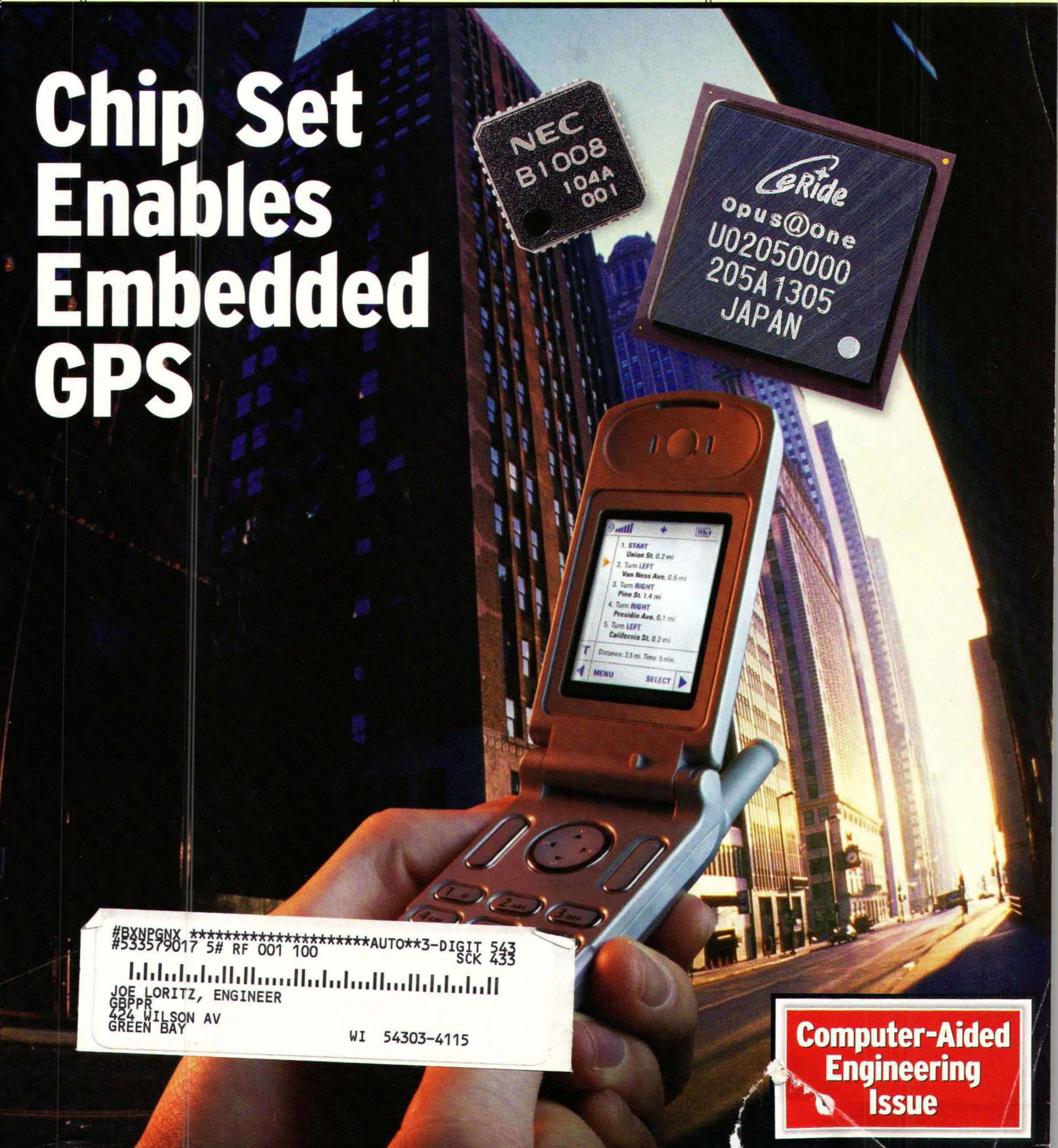
Microwaves & RF

News
Surveying the latest system simulators

Design Feature
Model an inductor for RFID applications

Product Technology
EDA suite expands MMIC capabilities

Chip Set Enables Embedded GPS



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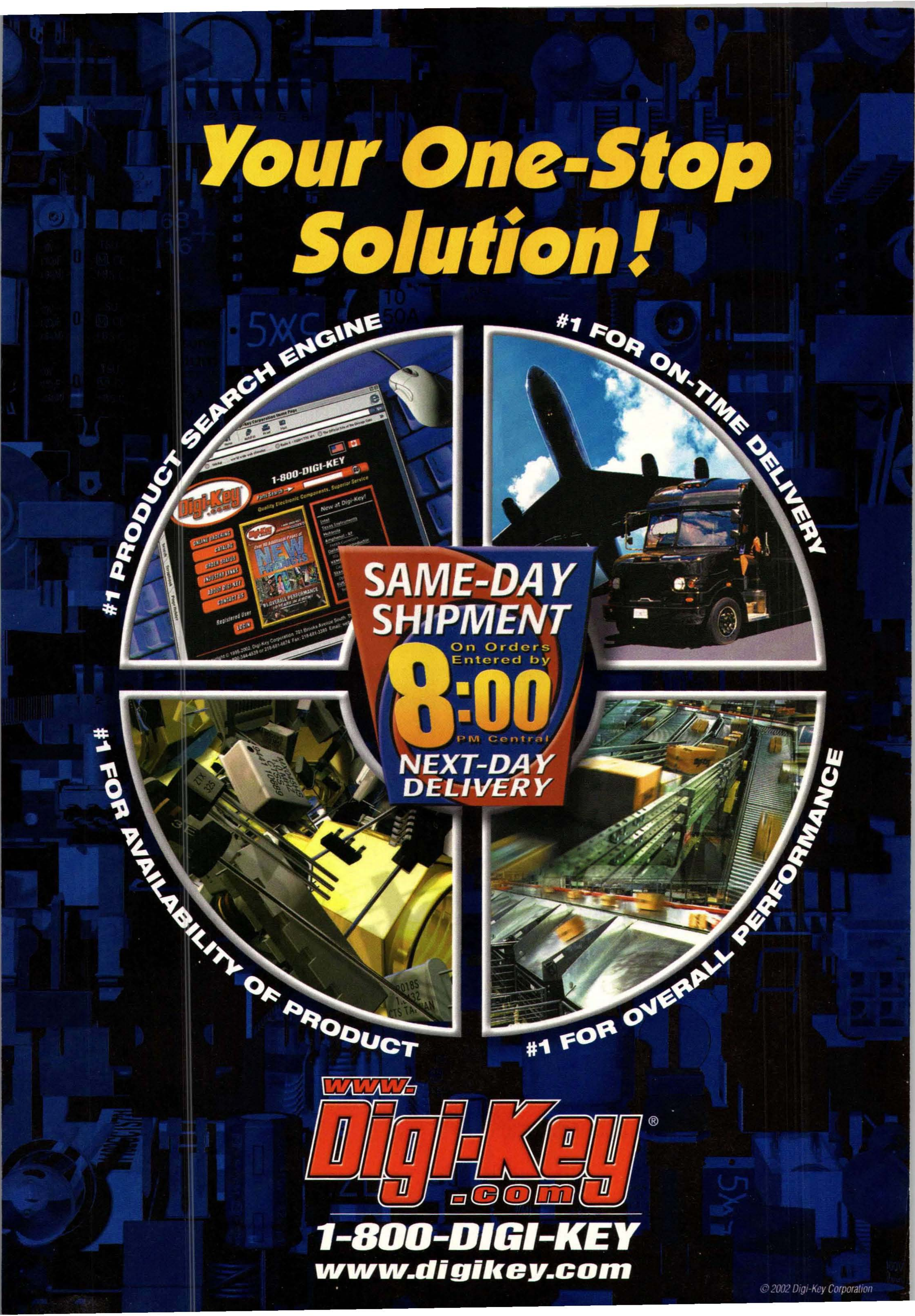
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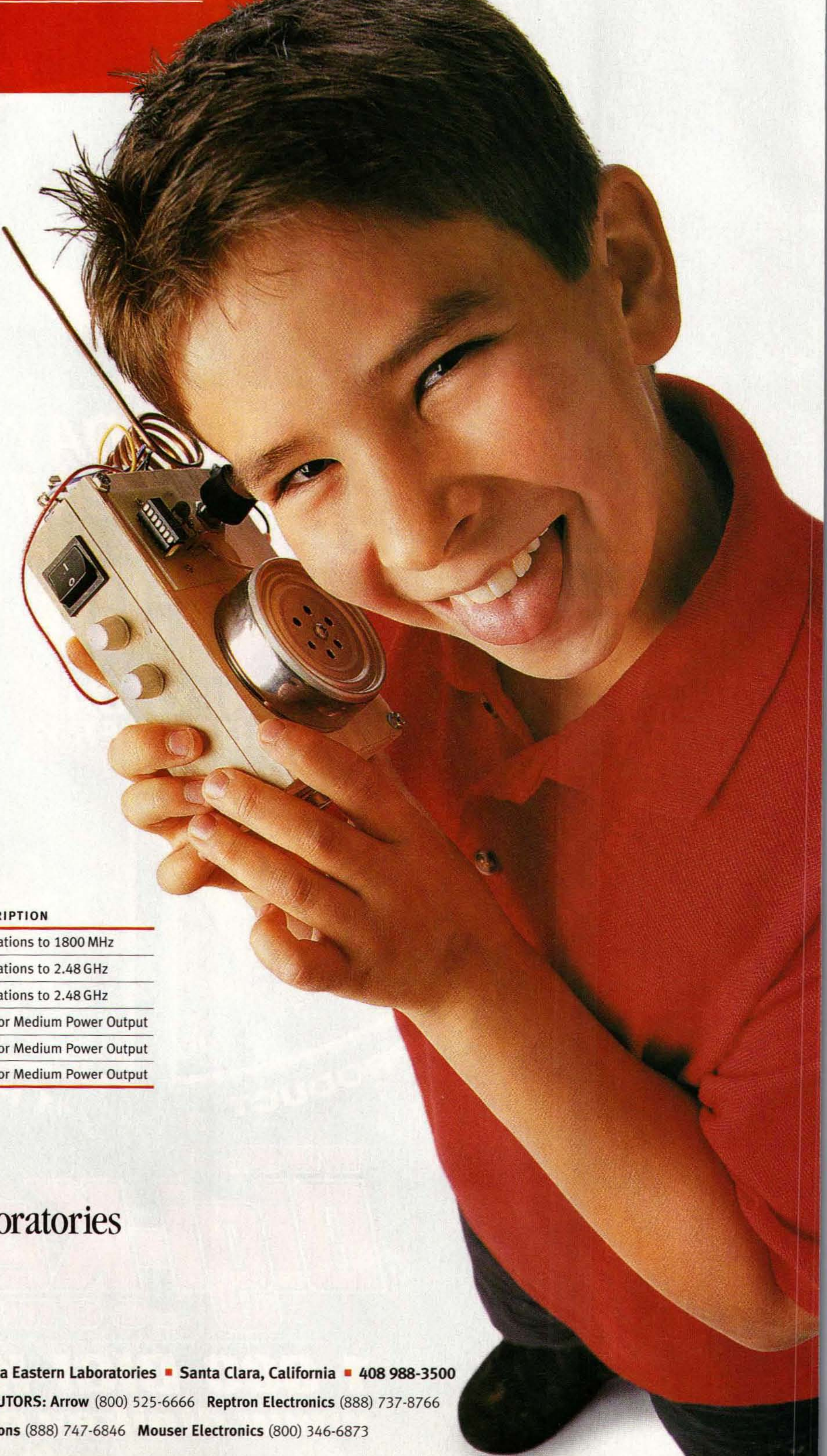

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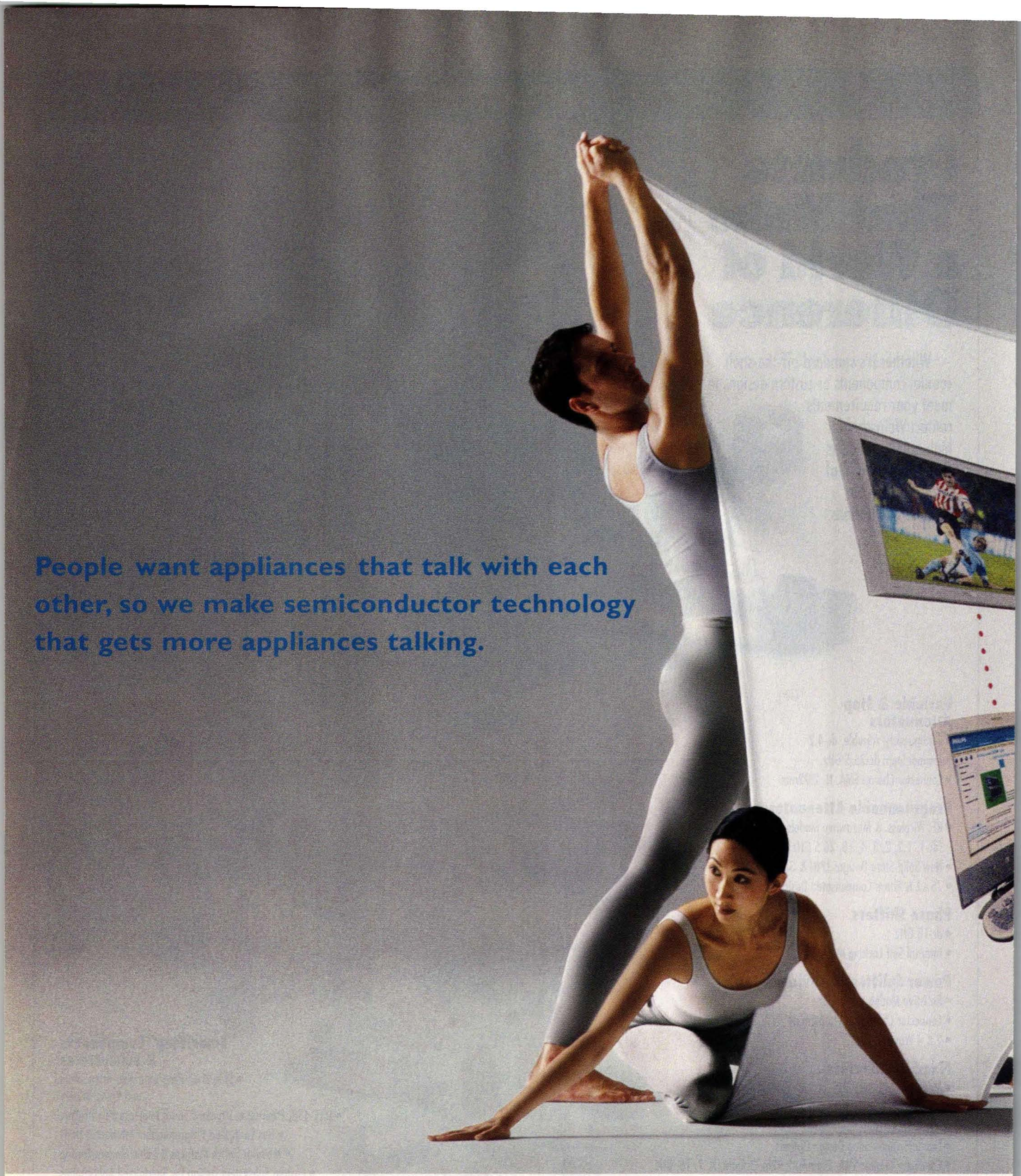
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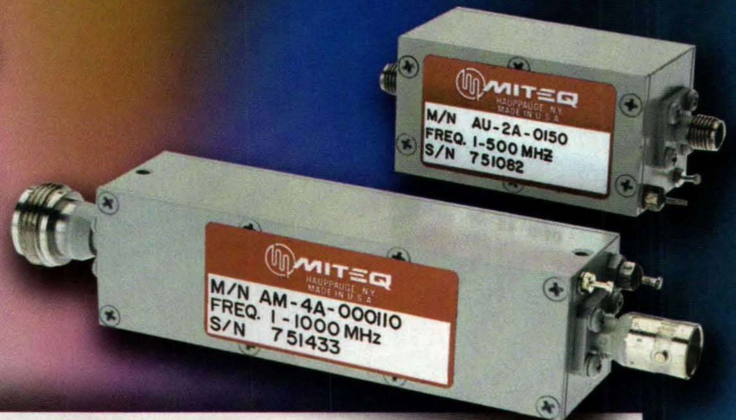

OPERATING FREQUENCY (MHz)	MODEL NUMBER	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	VSWR IN/OUT	NOISE FIGURE (dB, Max.) NF_1	NF_0	NF_2	OUTPUT POWER (dBm, Min.)
0.001 – 500	AU-1534	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 200	AU-1442	35	0.5	2.0:1	1.2	1.2	1.2	+5
0.01 – 200	AU-1447	56	0.5	2.0:1	1.2	1.2	1.2	+12
0.01 – 250	AU-1559	11	0.5	2.0:1	4.2	4.2	4.2	+16
0.01 – 400	AU-1565	54	0.75	2.0:1	1.2	1.2	1.3	+14
0.01 – 500	AU-1310	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 1000	AU-1402	18	1.0	2.0:1	6.0	5.0	5.0	+16
0.01 – 1000	AM-1300	27	0.75	2.0:1	1.4	1.6	1.8	+8
0.01 – 1000	AM-1431	35	0.75	2.0:1	1.4	1.6	1.8	+8
0.1 – 2000	AM-1364	9	1.5	2.0:1	6.0	6.0	6.0	+10
1 – 200	AU-1464	35	0.5	2.0:1	1.2	1.2	1.2	+6
1 – 400	AU-1421	24	0.5	2.0:1	2.4	2.4	3.1	+17
1 – 500	AU-2A-0150	30	0.5	2.0:1	1.3	1.4	1.5	+8
1 – 500	AU-3A-0150	44	0.5	2.0:1	1.3	1.4	1.5	+10
1 – 500	AU-4A-0150	60	0.75	2.0:1	1.3	1.4	1.5	+10
1 – 1000	AM-2A-000110	26	0.75	2.0:1	1.4	1.6	1.8	+6
1 – 1000	AM-3A-000110	35	0.75	2.0:1	1.4	1.6	1.8	+8
5 – 200	AUP-1568	26	0.75	2.0:1	5.0	4.5	4.5	+28
5 – 300	AUP-1495	11	0.75	2.0:1	15	9.0	9.0	+28
5 – 300	AUP-1496	23	0.75	2.0:1	8.0	7.0	7.0	+28
5 – 300	AU-1021	24	0.5	2.0:1	2.7	2.8	2.9	+20
5 – 300	AUP-1479	36	1.0	2.0:1	2.5	2.7	2.9	+28
5 – 1000	AM-1475	36	0.75	2.0:1	1.4	1.6	1.8	+15
5 – 2000	AM-1573	18	1.5	2.0:1	4.0	4.0	4.0	+21
5 – 2000	AM-1590	36	2.5	2.0:1	3.8	3.8	3.8	+20
5 – 2000	AM-1591	48	2.5	2.0:1	3.8	3.8	3.8	+20
100 – 1000	AM-1412	35	0.75	2.0:1	1.4	1.6	1.8	+14
100 – 2500	AM-1585	26	2.0	2.0:1	3.6	3.6	3.6	+20
200 – 2000	AM-1569	20	1.5	2.2:1	4.2	4.3	4.6	+14
1000 – 2000	AM-1477	37	1.0	2.0:1	1.8	2.1	2.4	+15

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New RF Ideas Are Needed

▶▶I FOUND JOHN DAVID'S letter, titled "The 'Team' Concept" and published in the November and December 2002 issues of *Microwaves & RF* (both p. 13), to be interesting and informative.

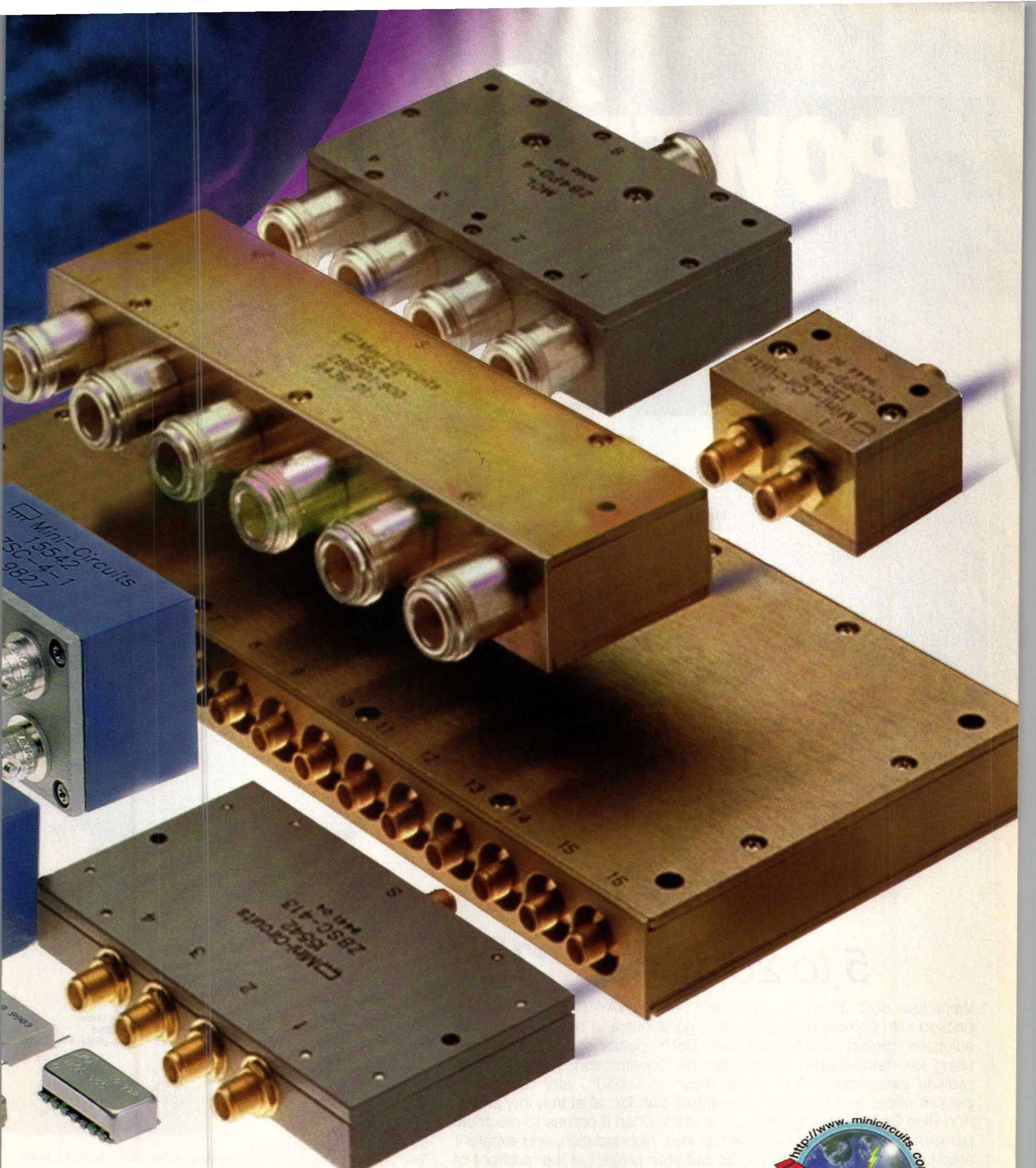
One can hardly complain about the lack of resources these days. There are a multitude of books, articles, and application notes covering every possible subject. Furthermore, anyone in any location can post a question on the Internet and receive answers from all over the world almost immediately. Never have more resources existed and never has the access to information been easier. It can even be argued that some individuals might find the abundance of information to be overwhelming.

Despite all that, one can really feel some pessimism today. Much of the abundance of information is just a "foam" and one can lose his energy when fishing in it. The spirit of the "pioneers'" era has really gone. Perhaps the time that we are living through could be known as the post-electronic era. Regardless of the label that you want to hang on these times, this era lacks the light spirit of the pioneers. Lots of problems seem to be solved and many designers just attempt to make something a bit better. Perhaps the RF field should shrink. How many gadgets do we really need? So, what worthy activities should we search for in this "post-electronic" era? One goal can be to blow away the "foam." I mean, the science is pretty spiced with trash. Many approaches have been discovered but not all are worthy. Many follow some ways which are neither clear nor right. I feel that words like "refinement," "revision," and "cleansing" should find use in the future. I have been trying something like this for years in oscillator theory and practice, and have found it to be difficult. The inertia is overwhelming and the facilities are scarce.

There is a need for some team concept, as John David said in his letter, some new mind set, some new attitude for the sharing of knowledge. But this could only be possible when the facilities exist for the unlimited communication of ideas. Internet forums, such as rfglobalnet, do not essentially help here. They make possible mere chatting, often silly chatting. They do not offer any substitute form of publication. And if anyone should consider any question seriously, make any measurement, draw any interesting conclusion, he would like to make it available for everyone within an extended period, not just the short-lived life span of a chat-room posting.

Stan Alechno
Rawar
alechno@wa.onet.pl

Editor's Note: This letter will continue in the March issue of Microwaves & RF.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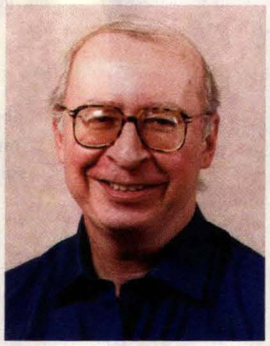
from the editor

Modeling Systems With Software



SYSTEM DESIGN WAS ONCE considered a "near-mystical" segment of high-frequency electronics. A few decades earlier, component suppliers were at the mercy of system designers from military contractors such as E-Systems, Martin Marietta, Raytheon, and Westinghouse when it came time to explain why their power divider, or amplifier, or filter wouldn't allow their system to meet its required performance specifications.

A growing number of system-level simulators are available on the commercial market.

In the modern era, system design tends to evoke images of cellular/PCS base stations, or repeaters, or digital radios in terrestrial links rather than the radar-warning receivers (RWRs) and interferometers of earlier electronic-warfare (EW) systems. Even given the sophistication of modern commercial communications systems, which rely on multiple-access and complex digital modulation formats, modern component suppliers have a huge advantage over their predecessors when dealing with systems designers: they now have access to computer-aided-engineering (CAE) programs that can reasonably estimate the performance of a system when different analog and digital components are connected together.

A growing number of system-level simulators are available on the commercial market, now mainly for personal-computer-based platforms (see the Special Report beginning on p. 33). Even for component-level designers who need not get involved with higher-level design, these simulation tools can provide tremendous insight into how a particular component behaves within a larger system. Knowing some of these system-level characteristics, for example, can provide a filter designer with invaluable knowledge when "negotiating" a set of performance specifications with a system-level customer.

A system-level simulator is a powerful tool, but not inexpensive. The operating interfaces for these software suites vary greatly, and the learning curve for proficiency on one of these complex software programs can often be as long as one year. In recognizing the need to simplify these tools for users who may lack system-level experience, many system-level CAE suppliers are to be commended for offering "design kits," which are essentially templates for a particular design, such as a Bluetooth radio or a WCDMA transmitter. And many more are providing detailed application-specific technical notes.

Not every component manufacturer needs a system-level simulator. But with access to such a tool, a component supplier can gain tremendous insight into system-level issues, and the language between component and system designers might become a bit less garbled.

Jack Browne

Publisher/Editor

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the front end

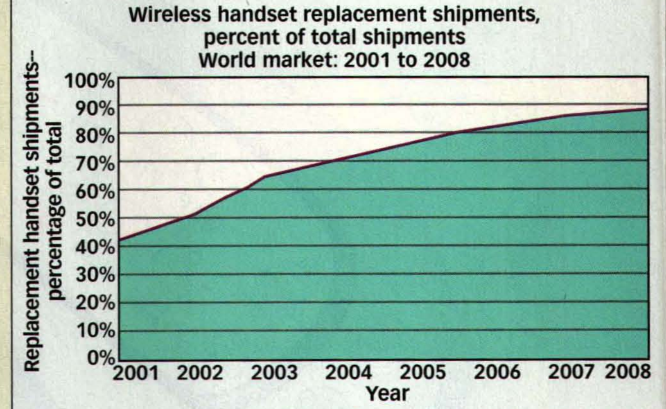
News items from the communications arena.

Smartphones Will Dominate Wireless Handset Market By 2008, Says ABI

OYSTER BAY, NY—A migration trend is emerging among wireless users toward feature-rich devices that incorporate color screens and advanced data and messaging applications, including navigation, multimedia messaging (MMS), and instant messaging, among others.

The primary catalysts of this trend are a combination of factors. For one, wireless handset penetration continues to grow, moving the market from one characterized by initial penetration to that of replacement with next-generation devices. Second, wireless operators are under increased pressure to drive higher average revenue per subscriber (ARPU) and are doing so by adding data services and "infotainment" content available to newer technology handsets.

According to a study from Allied Business Intelligence (ABI), the number of replacement handsets shipped will grow from 211 million in 2002 to 591 million units in 2008, representing approximately 85 percent of all shipments worldwide at that time **(see figure)**.



(Source: Allied Business Intelligence, Inc.)

The study, "Wireless Handsets, Smartphones and Communicators—The Convergence Of The Cell Phone & PDA And The Emerging 3G Network," also indicates that, of the estimated 406 million handsets shipped in 2002, only about 15 percent incorporated color displays. This number is expected to jump to 97 percent by 2008.

Power Amplifier Boosts Range And Efficiency Of RF Module

OTTAWA, ONTARIO, CANADA—SiGe Semiconductor announced that the RangeCharger™ PA2423L power amplifier (PA) is integrated into an RF module for use in 2.4-GHz DSS cordless telephones. Designed by Foryou Electronics Communication Ltd., the FY-2G4RF-001 RF module uses SiGe's wireless technology to enhance signal integrity for longer range, and to reduce current consumption for enhanced battery life.

"I am very pleased to be working with Foryou, as their RF module underscores our continued success delivering the benefits of silicon germanium to a wide range of 2.4-GHz applications," stated Bill Cuming, the vice president for optical cable and components at SiGe Semiconductor. "To date, the technology has been used in many Bluetooth and cordless-telephone devices, demonstrating the versatility of our technology to meet customers' output power, current consumption, and size requirements."

"We chose SiGe's power amplifier in part because of its exceptional performance, but also because of the support we received during our design phase," commented Zheng Jianbo, vice general manager at Foryou. "SiGe provided a reference design for the power amplifier and radio ICs that made it easy to bring our design from concept to manufacture in just a few months."

SiGe Semiconductor's PA2423L evaluation board and reference design provides designers with a complete model for designing complex RF front ends.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GPS Navigation Service For Mobile Phones Debuts

LAS VEGAS, NV—Televigation, a firm involved in wireless motion-based technology and services, has announced the debut of TeleNav™, North America's first Global Positioning System (GPS) navigation service for mobile phones. TeleNav gives owners of certain Java (J2ME) mobile phones the ability to navigate turn-by-turn to virtually any address in the continental US using a combination of real-time voice and graphical directions delivered directly to their phone.

Announced at the 2003 Consumer Electronics Show in Las Vegas last month, TeleNav costs $7.00 per month for the basic service (users must also subscribe to a wireless data service from their wireless carrier). TeleNav is user-centric instead of vehicle-centric, meaning that TeleNav subscribers can take the service with them from one vehicle to another.

"TeleNav has the great potential to really bring the GPS Navigation technology to the mass market," said Dr. H.P. Jin, president and CEO of Televigation. "Wireless mobile phones are the most ubiquitous personal technology device in use today; what's more, mobile phones have become a delivery point for a wide range of services that make them truly indispensable to the user. It's only natural to use mobile phones for GPS navigation."

"Mobile phones have become a delivery point for a wide range of services that make them truly indispensable to the user."

To use TeleNav, subscribers first enter their destination by using a voice-recognition system or by typing in the address on their Java phone. Once the address is entered, the user starts the TeleNav Java application, after which TeleNav provides real-time, turn-by-turn directions based on the user's current location.

Real-time turn-by-turn direction messages are displayed on the mobile phone's screen and audibly played via speakerphone. The screen displays the name of the street where the next turn is to be made, as well as an appropriate turn arrow and real-time distance to the turn. If the user makes a wrong turn or changes course, the system automatically re-routes the user to the original destination.

RFMD Discusses Financial Performance At Conference

NEW YORK, NY—RF Micro Devices, Inc. (RFMD), a provider of proprietary RF integrated circuits (RF ICs) for wireless-communications applications, commented on the company's fiscal 2003 third and fourth quarters at the recent Needham & Co. Growth Conference.

Bob Bruggeworth, president of RFMD, outlined the company's long-term growth prospects, and Dean Priddy, CFO of RFMD, discussed the company's financial performance.

Bruggeworth indicated that RFMD believes it is experiencing market-share gains in handsets and in wireless-local-area-network (WLAN) products. He commented further that RFMD expects sustainable long-term growth through continued power-amplifier (PA) market-share gains in code-division-multiple-access (CDMA) and Global System for Mobile Communications (GSM) handsets, increased sales of small-signal devices in handsets, ongoing WLAN market-share gains, and, later, demand for Bluetooth™, GPS, and high-powered PAs for wireless infrastructure.

Regarding the fiscal 2003 third quarter ended December 31, 2002, Priddy stated that he expects that financial results will be at least at the high end of the range of $128 to $132 million in revenues and $0.04 to $0.05 in earnings per share, before one-time items related to the acquisition of Resonext Communications and the buyout of RFMD's synthetic lease, both of which were announced in December 2002. RFMD also commented that operating income, which improved 300 basis points in the September 2002 quarter, is expected to continue to improve in the December 2002 quarter.

Regarding the fiscal 2003 fourth quarter ending March 31, 2003, RFMD indicated that it is already fully booked to exceed current consensus revenue estimates.

Priddy stated, "The Company appears to be experiencing a growth spurt and is breaking out of its historical revenue range of approximately $100 million per quarter. We believe we are either taking huge chunks of market share or the market is growing, or both. From our viewpoint, we think it's a combination of both. We believe this growth is sustainable in the near term, and we expect our strategic growth initiatives in wireless LAN, Bluetooth, GPS, infrastructure, and other markets position us for long-term growth and operating income improvements."

RF Micro Devices is an ISO 9001-certified manufacturer and is traded on the Nasdaq National Market under the symbol RFMD.

GSM Is The Americas' Fastest-Growing Wireless Technology

BELLEVUE, WA—Global System for Mobile Communications (GSM) has become the fastest-growing wireless technology in the Americas, registering a 37-percent year-over-year growth through September 2002, according to the EMC World Cellular Database. GSM subscribers globally totaled more than 745 million subscribers representing growth of 28 percent during the same 12 months.

Chris Pearson, executive vice president of 3G Americas predicted, "We are seeing the beginning of explosive growth of GSM in the Americas. TDMA operators in North America are delivering on schedule their GSM/GPRS deployments, creating a national footprint of wireless data services for their customers. This is the food to fuel the uptake of customer services such as photo-messaging, entertainment, always-on anywhere anywhere Internet connectivity, and corporate enterprise e-mail."

"We are seeing the beginning of explosive growth of GSM in the Americas."

GSM is the world's leading wireless technology, and as of today there are more than 785 million subscribers worldwide, representing nearly 72 percent of all digital cellular subscribers today. Another 13 percent of the world's digital subscribers are code-division multiple access (CDMA) and 10 percent are time-division multiple access (TDMA). GSM provides an unmatched roaming footprint spanning more than 550 networks in more than 184 countries.

According to EMC, as of September 2002, there were 100.7 million TDMA subscribers in the Americas, 83.7 million CDMA subscribers, and 21 million GSM subscribers. Another 27.8 million analog subscribers are represented, although this number declined by over 30 percent in the last 12 months.

Kudos

GREENVILLE, NC—Lawrence Behr, CEO and founder of the LBA Group, Inc., has been named a 2002 Fellow of the Radio Club of America. The award was bestowed at the RCA 93rd Annual Awards Banquet and Technical Symposium held at the New York Athletic Club in New York City.

The award recognizes Mr. Behr's expertise and contributions in the field of wireless communications over a period of more than 40 years.

WASHINGTON, DC—The Wireless Communications Association (WCA) has bestowed its highest annual leadership award for governmental vision to wireless broadband standardization pioneer Dr. Roger B. Marks. The award was given to Dr. Marks during the WCA's Ninth Annual Technical Symposium and Business Expo.

During a dinner on January 14 following his luncheon keynote on January 13, Dr. Marks received WCA's Individual Governmental Vision Award for his longstanding efforts in promoting standards for broadband wireless as a way to increase interoperability and otherwise lower costs to enable widespread deployments. He founded in 1998, and has since chaired, the IEEE 802.16 Working Group on Broadband Wireless Access Standards, which is a unit of the Institute of Electrical and Electronics Engineers (IEEE).

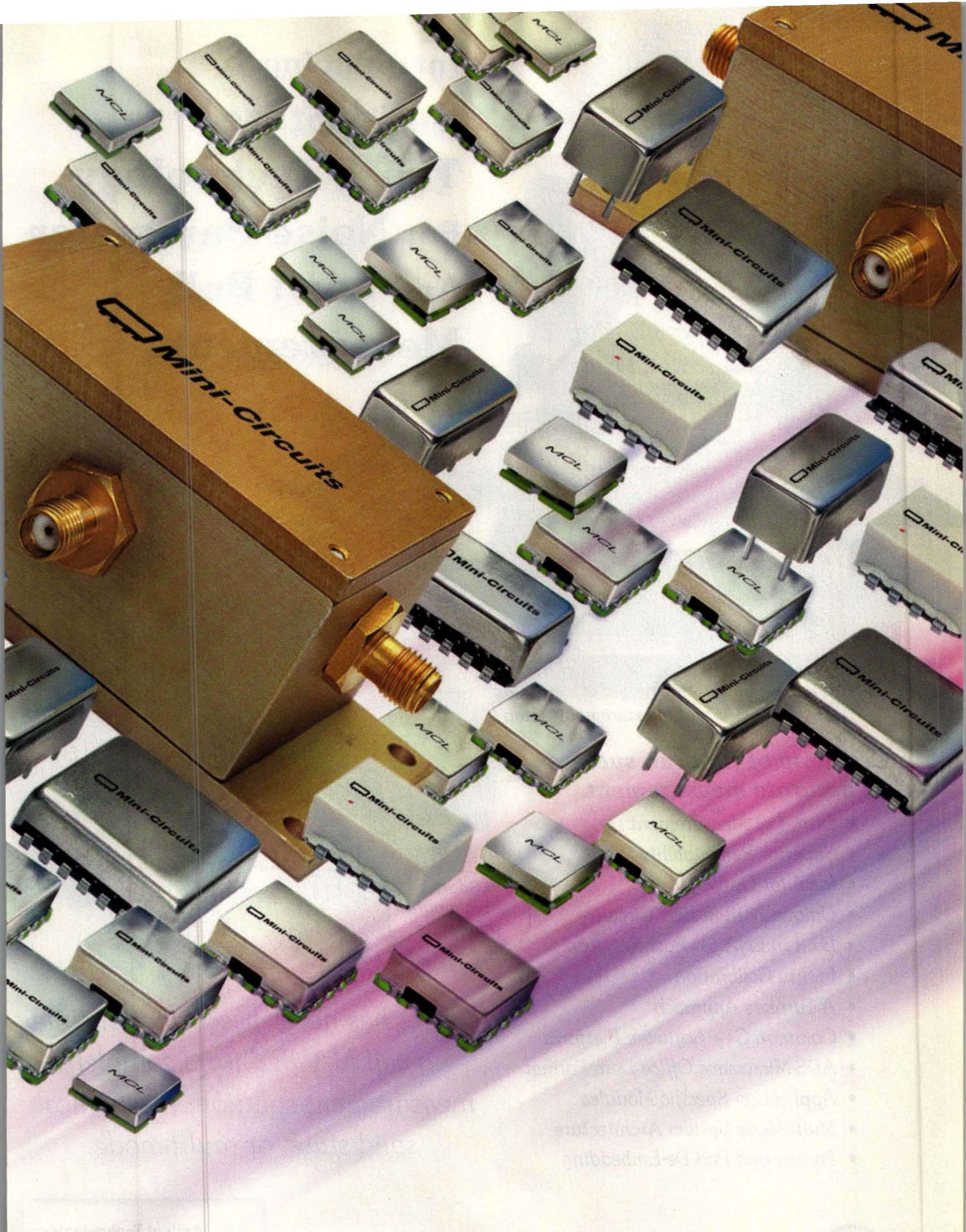
BENSENVILLE, IL—Magnetic Shield Corp. has successfully completed the process of ISO9001:2000 registration through Perry Johnson Registrars, Inc.

Registration provides objective proof that Magnetic Shield Corp. has implemented an effective quality management system that is satisfying all of the requirements of the ISO9001:2000 standard. These requirements include standards for: management responsibility; resource management; product and/or service realization; and measurement, analysis, and improvement.

ALPHARETTA, GA—Verizon Wireless announced that they are collaborating with the Georgia State Patrol's Safety Education Division to promote safer and more responsible driving.

As part of Verizon Wireless' efforts to promote safer cellular-phone use while driving, the company is providing the Georgia State Patrol's Safety Education Division with an instructional video. The video was created by Verizon Wireless to educate new drivers about the importance of driver safety. The Safety Education unit will use the materials from Verizon Wireless in their statewide driver safety education programs. Verizon Wireless also provided each instructor in the Safety Education unit with ear buds. It is hoped that if drivers are going to use cell phones while driving, they will use the more responsible hands-free method.

AUSTIN, TX—Wireless Valley Communications, Inc. has been awarded US Patent 6,493,679 for a network-design and asset-management invention. MRF


Mini-Circuits
MCL

NEWS

Simulators Model System Behavior

The latest collection of system-level software simulators bring workstation-like modeling power and ease of use to the personal computer.

JACK BROWNE
Publisher/Editor

System design was once the demesne of a chosen few engineers who understand the behavior of different high-frequency functions working together. As more functions become integrated together onto common substrates and housings, however, it is more incumbent upon RF/microwave engineers to gain at least a fundamental understanding of system-level dynamics. Fortunately, with the emergence of powerful system-simulation software, designers can now model the most complex analog and digital system-level functions on a standard personal computer (PC).

System-level simulators are currently available from a number of dependable suppliers, including Agilent Technologies (Santa Rosa, CA), Ansoft (Pittsburgh, PA), Applied Wave Research (El Segundo, CA), Cadence Design Systems (San Jose, CA), Eagleware Corp. (Norcross, GA), Elanix (Westlake Village, CA), and Mentor Graphics (Beaverton, OR). For example, SPECTRASYS is a spectral-domain system simulator from Eagleware Corp. (www.eagleware.com) that complements the company's lineup of linear and nonlinear simulators, including SUPERSTAR and HARBEC, and electromagnetic (EM) simulation tools, such as EMPOWER. The system-level software is in keeping with the philosophy of the company's other design tools: provide a high level of accuracy in an easy-to-use package.

SPECTRASYS, which is a design module for the firm's GENESYS software suite, allows engineers to analyze full-node spectra at any node in a design. Operators can analyze parallel paths, view the phase of any spectral component, and identify the paths of any spectral component throughout the system. Rather than define each path in a system, the SPECTRASYS program allows an operator to create a single schematic diagram with any arbitrary topology, and then specify any path of interest for analysis, rather than creating a new schematic diagram for each spectral path.

SystemView from Elanix (www.elanix.com) has long been used by designers of both commercial and military systems. On the commercial side, the software has been used to model Bluetooth, wireless local-area network (WLAN), cellular/personal communications services (PCS), and various spread-spectrum communications systems. On the military side, the software has been used to model direction-finding (DF), electronic-intelligence (ELINT), radar, signal-intelligence, and sonar systems. The software, which allows operators to connect and manipulate function "tokens" to construct sophisticated analog, digital, and mixed-signal systems, allows analysis of

a wide range of system signal characteristics, including magnitude, power spectral density, phase, and group delay. It allows the simulation of mixed time-continuous and time-discrete systems, multirate systems, multiple parallel systems, and distortion in RF and analog systems. The software is supported by a full complement of logic functions, switches, and nonlinear devices, and includes full libraries of sources, sinks, functions, operators, and MetaSystems (which are essentially multiple-function modules).

The company recently announced a pair of new application notes devoted to one of the more significant emerging wireless technologies: ultrawideband (UWB) communications. Available for free from the firm's website, these application notes (see p. 110 for a review) cover the simulation of UWB transmitters (Txs) and receivers (Rxs) based on both pulse-position modulation (PPM) and on/off-keying (OOK) modulation.

New application notes from Elanix, for example, highlight simulations of UWB Rxs and Txs based on pulse position modulation (PPM) and on-off-keying (OOK) modulation. UWB technology is based on the use of modulated pulses to send high-rate data at extremely low transmitter power levels (a few milliwatts). Although the pulses can occupy several gigahertz of bandwidth, they are transmitted at power levels designed not to interfere with existing applications within the operating bandwidth, including Global Positioning System (GPS), cellular systems, and WLAN systems.

Another relatively new modeling tool, the Visual System Simulator 2002 (VSS2002) from Applied Wave Research (www.mwoffice.com) features specialized "Design Studio" modules to speed and simplify the modeling of specific wireless systems. For example, the 802.11a Design Studio for VSS2002 models all the signal generation and measurements needed for evaluating wireless systems according to the IEEE Std 802.11a-1999 specifications (data rates as high as 54 Mb/s). Operators have access to a transmitter's complex offset-frequency-division-multiplex (OFDM) envelope as well as to the in-phase/quadrature (I/Q) constellation. Users can select the number of data bytes per frame, the number of samples to overlap the OFDM symbol, the oversampling rate, and the frame length. Operators can also turn off OFDM subcarriers individually or in groups.

The company's 3G Design Studio for VSS2002 supports the simulation and evaluation of third-generation (3G) wideband code-division-multiple-access (WCDMA) equipment for base stations and user equipment. The software is compliant with the latest Third Generation Partnership Program (3GPP) specifications (revision 3.9). All of the baseband processing found in a 3G system, including framing, encoding, interleaving, spread-

ing, and rate matching, can be handled by the 3G simulation function blocks. The simulation tool handles uplinks and downlinks at data rates of 12.2, 64, 144, and 384 kb/s.

Ansoft Designer from Ansoft (www.ansoft.com) combines time, frequency, and system analysis capabilities within a common framework. It blends EM analysis with circuit- and system-level simulation and a new capability (called "Solver on Demand") to automatically select the best solver for a given simulation task. The software suite includes Full-Wave Spice for time-domain analysis, along with nonlinear simulation and digital communications systems simulation with support for systems through 3G configurations.

The Advanced Design System 2002C from Agilent Technologies (www.agilent.com) is the latest version of a powerful system-level design environment that may well be the tool of choice for designers of integrated-circuit (IC) systems on a chip (SoC). The software seamlessly combines device-, circuit-, and system-level simulation engines and models with connectivity to commercial test equipment. This latest version includes an improved tuning model, new 3G source models, enhancements to artwork importing functions, and new Ptolemy models.

The MMICAD suite (see p. 64) of software tools from Optotek (www.optotek.com), which is also commonly used by designers of ICs, is well suited for designers of SoC. The system suite supports filter synthesis, time-domain transient analysis, and small- and large-signal device modeling.

Version 2.0 of TESLA for Windows from Tesoft (www.tesoft.com) speeds the simulation of complex systems at the block-diagram level. The first true systems-level software simulator (introduced in 1988), TESLA works with OrCAD Capture for Windows to first create a block diagram model for simulation; operators can switch back and forth between Capture (for block-diagram creation) and TESLA (for simulation) with a single keystroke.

Last but not least, two system-level tools from software giants Cadence Design Systems (www.cadence.com) and Mentor Graphics (www.mentor.com) provide powerful analysis capabilities for both PC and workstation users. Cadence's OrCAD Unison Suite is a complete solution for front-to-back printed-circuit-board (PCB) design, with schematic capture, analog, digital, and mixed-signal simulation, layout tools, and autorouter functions. Mentor's SystemVision is a math-based prototyping tool that includes extensive model libraries, graphical-design tools, data-analysis tools, and model-creation tools. It can handle analog, digital, and mixed-signal electrical models as well as electromechanical, thermal, and hydraulic models. MRF

European Event Offers Snapshot Of RF Technology

The RF & Hyper Europe 2003 brings an international audience to France for three days of product displays and technical talks on EMC issues.

JACK BROWNE
Publisher/Editor

European and international design engineers have long known that the RF & Hyper conference and exhibition each year has provided several days packed with educational meetings, course, and product exhibits on the latest RF and microwave developments. The latest, 29th edition of this event, the RF & Hyper Europe 2003, is scheduled for April 1-3, 2003 in Halls 1 and 2 of the Paris-Expo, Porte de Versailles, France.

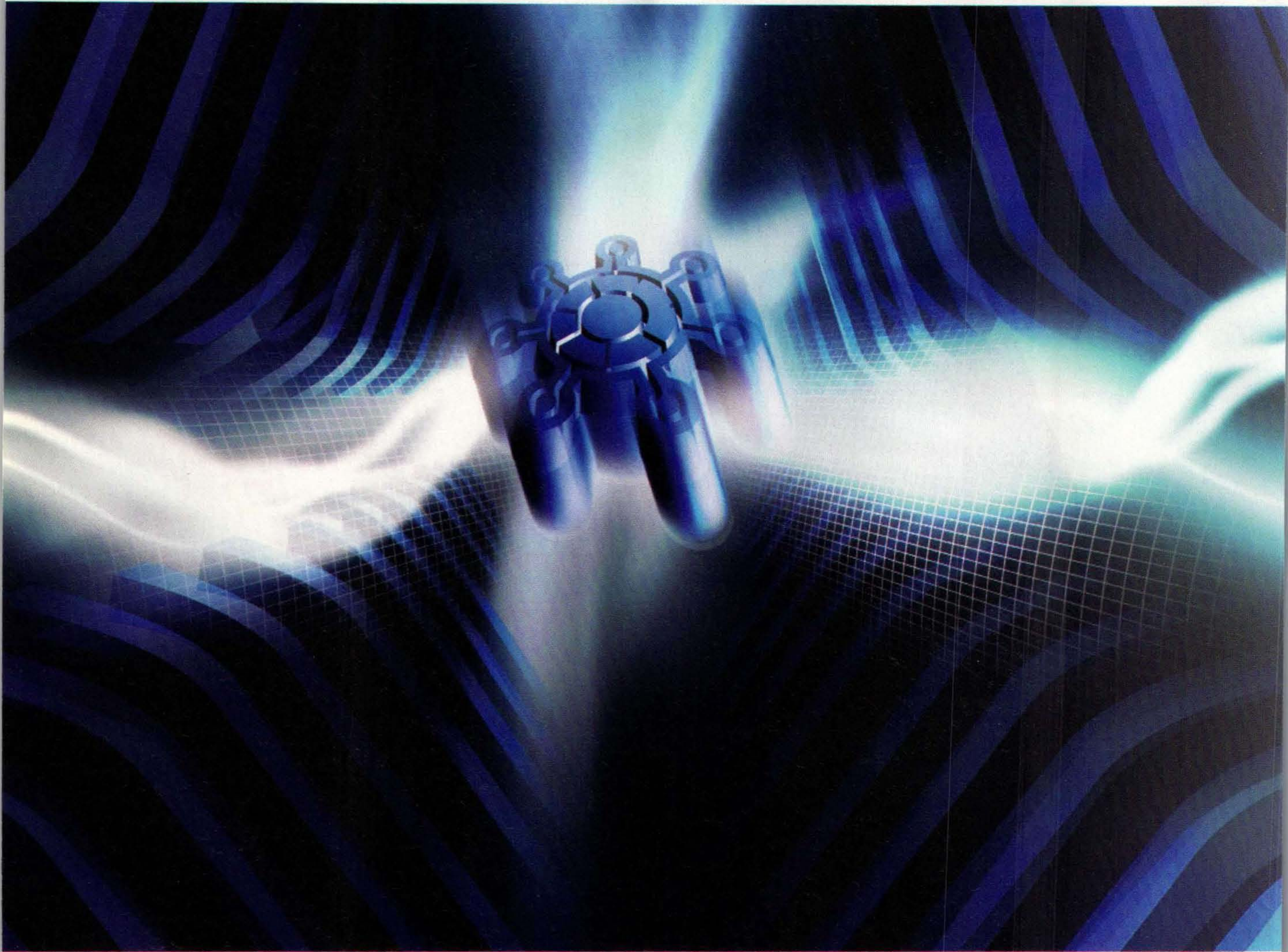
In 2002, the combined attendance of exhibitors and technical conference visitors was over 4800, up from slightly more than 4500 in 2000. In spite of the challenging economic conditions, the show's organizers feel that the 2003 edition of the conference and exhibition should show an increase in attendance over 2002.

The RF & Hyper Europe 2003 offers a comfortable blend of technical presentations and exhibit booths. Several hundred exhibit booths are expected, including such leading North American firms as Agilent Technologies (Santa Rosa, CA), Ansoft (Pittsburgh, PA), MITEQ (Hauppauge, NY), and Focus Microwaves (St.-Laurent, Quebec, Canada), and such leading European suppliers as MATECH Electronique, Thales Microelectronics, Wessex Electronics, and Temex.

For those interested in the latest technical developments in electromagnetic compatibility (EMC) or compatibilite electromagnetique (CEM), the RF & Hyper Europe 2003 is also the site for EMC presentations organized by the Association Francaise de Compatibilite Electromagnetique (AFCEM). These presentations are organized into four sessions held on April 1 and 2. The first session, on general CEM, includes presentations on the effects on aging on EMC filters and the challenge of achieving proper CEM in tunnels. The second session includes presentations on protecting against EM radiation and industry contributions to the drafting of the UTE C 99-111 guide. The third session includes presentations on optimizing EMC in wiring for transportation systems.

The last EMC session, on market regulation and EMC techniques, features presentations on conformity requirements for WiFi and wireless local-area networks (WLANs) at 2.4 and 5 GHz.

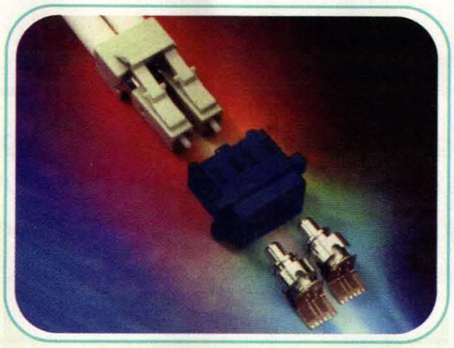
In addition to the EMC conference, the RF & Hyper Europe 2003 event features presentations in the form of application/product-based presentations by exhibitors. For more information about RF & Hyper Europe 2003, contact Sylvie Cohen or Carine Dumas, BIRP, 11 rue du Perche, 75003 Paris, France; (33) 144789930, FAX: (33) 144789949, e-mail: hyper@birp.fr, Internet: www.burp.com. MRF



Optical Front-End Chips Support 10-Gb/s Designs

THE TO-FLEX OPTICAL front-end chip set is designed for low-cost, multistandard 10-Gb/s optical communications systems. The chip set consists of an optical receiver with PIN photodetector and transimpedance amplifier (TIA) to convert 850-nm-wavelength optical signals to electrical data and an 850-nm vertical-cavity surface-emitting laser (VCSEL) transmitter. The company also offers limiting amplifiers and laser driver amplifiers to equip optical-transceiver designers with a complete four-chip solution for high-speed, 850-nm optical communications. The receiver consumes only 125 mW power but provides sensitivity of –14 dBm. The transmitter offers typical output power of 1.5 mW at 9 mA and operates at rates to 12.5 Gb/s.

OEpic, Inc., 1231 Bordeaux Dr., Sunnyvale, CA 94089; (408) 747-0388, FAX: (408) 747-5808, Internet: www.oepic.com.



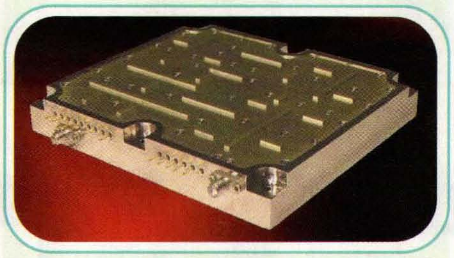
OEPIC TO-FLEX OPTICAL CHIP SET

OPHIR RF REDUNDANT POWER-AMP SYSTEM

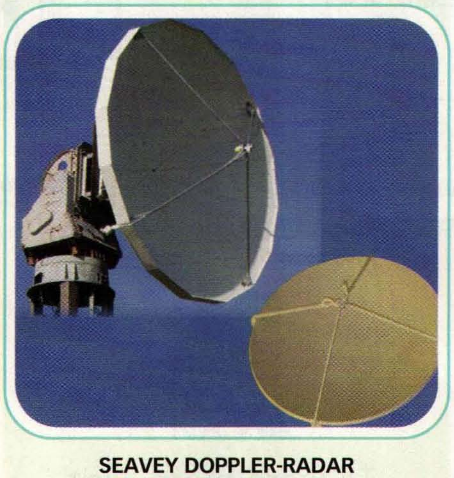
Single Phase-Locked DRO Switches Six Frequencies

A SERIES OF PHASE-LOCKED dielectric-resonator oscillators (DROs) features single sources capable of switching among six frequencies (and optionally as many as nine frequencies) across bandwidths as wide as 20 percent from 1 to 26 GHz. The PLS series multiple-frequency DROs feature phase noise of only –110 dBc offset 10 kHz from a 10-GHz carrier. The compact phase-locked sources feature low microphonics, low DC power consumption, and a package size that measures only 3.55 × 3.5 × 0.69 in. With their multiple-frequency capabilities, these DROs are ideal for use in wideband receivers (Rxs) and in multiband frequency converters.

Elcom Technologies, Inc., 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030, FAX: (201) 767-0542, Internet: www.elcom-tech.com.



ELCOM TECHNOLOGIES MULTIFREQUENCY DRO



SEAVEY DOPPLER-RADAR ANTENNAS

Amplifier Systems Power 800 To 1000 MHz

MODEL 5130 IS A 200-W redundant amplifier system available for any 60-MHz instantaneous bandwidth from 800 to 1000 MHz. The system consists of two 125-W power amplifiers (PAs) and a controller in a rack-mounted configuration. Should one of the amplifiers fail, the system output power will drop by only 6 dB. The minimum rated output power is 150 W at 1-dB compression, with 25-dB nominal gain and ±1-dB worst-case gain flatness. The saturated output power is typically 200 W. Rated spurious levels are –60 dBc at 150 W while the rated third-order intercept point is typically +62 dBm. The 50-Ω, Class A/AB PA system features forced-air cooling and is designed for operating temperatures from 0 to +50°C.

OPHIR RF, 5300 Beethoven St., Los Angeles, CA 90066; (310) 306-5556, FAX: (310) 577-9887, Internet: www.ophirrf.com.

Doppler Radar Antennas Span S-Band To Ka-Band

A LINE OF DOPPLER RADAR antennas has been developed for such applications as weather and environmental testing, typhoon warning, tornado tracking, and general weather-prediction applications. The antennas range in size from 8 ft. in diameter to 2 ft. in diameter, at frequencies from S-band to Ka-band, respectively. They are designed to handle peak RF power levels ranging from 50 to 550 kW, and feature dual-linear-polarization capability. The antennas offer outstanding sidelobe suppression and excellent cross-polarization performance. All antennas have a dual-polarized feed system with waveguide running to the edge or rear of the antenna reflector.

Seavey Engineering Associates, Inc., 28 Riverside Dr., Pembroke, MA 02359; (781) 829-4740, FAX: (781) 829-4590, Internet: www.seaveyantenna.com.

Semiconductor Growth Is Forecast

ENDING TWO YEARS of downturn, the worldwide semiconductor, electronic equipment, and component markets will return to robust growth in 2003, according to the latest forecasts from iSuppli Corp. Market Intelligence Services.

Worldwide semiconductor sales in 2003 will rise to $171.6 billion, up 11.8 percent from $153.5 billion in 2002, iSuppli estimates. This growth rate is a sharp contrast with the plunge of 31.9 percent in 2001 and last year's small rise of 1.5 percent.

"The semiconductor industry's stronger growth in 2003 will be driven by an across-the-board expansion of sales in the electronic equipment markets," predicted Gary Grandbois, principal analyst with iSuppli. "Semiconductor revenues also will be boosted by the resolution of excess inventory issues, which depressed semiconductor revenues in 2001, and even in 2002," he added. Grandbois authored the report. *2003 Squeaks into Double Digits*, which presents iSuppli's updated semiconductor, electronic equipment, and component forecasts for 2003 and beyond.

Sales of electronic equipment—a category consisting of data processing, wired communications, mobile communications, consumer, automotive, and industrial—will rise to$1.03 trillion in 2003, up 6.8 percent from $965.6 billion in 2002. This follows a 3.4-percent sales decline in 2002. The biggest story in electronic equipment in 2003 will be sales of wired-communications gear, which will return to growth after two years of plunging revenues.

Sales of electronic components—a category consisting of semiconductors, passives, electromechanical devices, batteries, and displays—will rise by 10.5 percent in 2003, according to predictions from iSuppli. This contrasts with modest growth of 3 percent in 2002. Displays will lead the electronic component markets in 2003, with 15-percent growth. The strong rise in display sales partly is due to the desktop personal-computer (PC) monitor market's rapid adoption of flat-panel displays, which are more expensive than the CRT monitors that they are replacing, thus driving up revenues. MRF

CONTRACTS

Qualcomm, Inc.—Announced that KTF, a South Korean wireless operator, has extended its contract to provide a wireless-application service based on Qualcomm's Binary Runtime Environment for Wireless™ (BREW) platform, an end-to-end solution that enables over-the-air downloading of applications.

Motorola—Has been awarded an expansion contract for its Global System for Mobile Communications (GSM) in South India by Bharat Sanchar Nigam Ltd. (BSNL). Under terms of the $33 million contract, Motorola will install a GSM network for BSNL in Chennai and expand its existing network of Andhra Pradesh in nine cities, including Hyderabad. The network expansion and deployment, scheduled to be completed by April 2003, will provide BSNL with additional subscriber capacity of 313,000. The cities to be covered are Hyderabad, Vishakapatnam, Vijayawada, Guntur, Kakinada, Amalapuram, Tirupathi, Warangal, and Rajamundry.

The current expansion contract is in addition to the initial $170 million contract awarded by BSNL for the deployment of the GSM cellular network in South India and announced in early 2002. Under that initial contract, Motorola deployed the GSM cellular network for a region in the four States of Andhra Pradesh, Tamil Nadu, Karnataka, and Kerala. The total capacity of the network deployed by Motorola for BSNL in the south will now total approximately 1.7 million subscribers.

FRESH STARTS

RF Micro Devices, Inc.—Acquired Resonext Communications, Inc., a privately held company providing complementary-metal-oxide-semiconductor (CMOS) wireless-local-area-network (WLAN) solutions 802.11a and multiband (802.11a/b/g) platforms.

TMD Technologies Ltd.—Has appointed Hypertech S.A. as its new agent for France.

Based near Paris, Hypertech S.A. has been established for more than 16 years and is an approved supplier to most French original-equipment manufacturers (OEMs), including Thales, Alcatel, and EADS.

Phihong—Announced the opening of a new sales office in Devon, England. The new office joins existing sales offices in Brazil, China, Japan, Taiwan, and the US.

To reach the England office, call +44 (0) 1271-343479, or write: Phihong Europe, P.O. Box 196, Barnstaple, Devon EX31 2XJ, England.

Wide Band Systems, Inc. Defense Systems Division—Has relocated to a new 10,000-sq.-ft. facility in Newtown, PA from its former location in Neshanic Station, NJ.

NDK America, Inc.—Announced that NRS Technologies, Inc., a subsidiary of NDK, completed the acquisition of NEC's surface-acoustic-wave (SAW) device business. NRS becomes a joint venture of NDK (85.1 percent) and NEC (14.9 percent). NEC's SAW filters employ hollow plastic package technology, which will complement NDK's current SAW filters and resonator products.

Rockwell Collins—Has become the first in the industry to receive Federal Aviation Administration Technical Standard Order approval for a Multi-Mode Receiver (MMR) equipped with Microwave Landing System (MLS) functionality that can be implemented in both commercial and military aircraft.

Rockwell Collins' MMR is an integrated unit providing VHF Omnidirectional Range (VOR), Instrument Landing System (ILS), Marker Beacon, Global Positioning System (GPS), and MLS functions.

MICRO-COAX—Acquired the assets of the Coaxitube Division of Precision Tube Co. Coaxitube's manufacturing operation will be consolidated into MICRO-COAX's ISO 9002-certified facility in Pottstown, PA.

Racal Instruments, Inc.—Announced that it is assuming sales and delivery support for all of Talon Instruments' and C&H Technologies' products. Racal has signed an exclusive distribution contract with Talon for North America, which extends the geographical scope of the agreement that has existed between the two companies in the balance of the international market for the last seven years. The exclusive distribution agreement between C&H and Racal is also worldwide in scope.

Northrop Grumman Corp.'s Sperry Marine Business Unit—Has come to a partnership agreement with Thrane & Thrane AS under which Sperry Marine will market the Capsat® Fleet 77 Broadband Satellite Communications System, designed to support the increasing demand for higher-speed data connections between ship and shore.

Under the agreement with Thrane & Thrane, Sperry Marine will offer a broadband satcom terminal as part of its extensive suite of integrated navigation, communications, and ship control systems.

Andrew Corp.—Announced the establishment of the Andrew China Research & Development Center in Suzhou, Jiangsu, People's Republic of China. The new center joins the company's global R&D network and will become a hub for researching and developing base-station antennas, connector products, accessories, and filters for worldwide wireless-communications markets.

Aeroflex, Inc.—Has acquired substantially all of the assets of FastBit Technologies, Inc., consisting of the equipment, inventory, and intellectual property specific to the FB100A Bit Error Rate Test System, the FBA2000A Frequency Tuneable Carrier-to-Noise Test System, and the FB3000A QPSK/QAM Digital CATV RF Modulator.

Palomar Technologies—Acquired the Fiber Automation Division (FAD) of Axsys Technologies. The new organization, Palomar Photonics Automation, will continue operations in its Pittsburgh, PA facility. MRF

HENDRY

Link Microtek Promotes Hendry To Sales Manager

STUART HENDRY has been promoted to the position of sales manager at Link Microtek Ltd., a supplier of RF and microwave components. Prior to joining Link Microtek, Hendry was employed at English Electric Valve as senior production engineer.

Celerity Digital Broadband Test—JIM BALENT to L-3 Communications corporate channel manager; formerly business development manager and product marketing manager at National Instruments. Also, ED OKORN to sales manager for the Northeast region of the US; formerly Commercial Sensors sales manager at General Electric. In addition, BOB LOVILL to Southeast regional sales manager; formerly account manager with Agilent Technologies.

Verizon—ALAN CIAMPORCERO to president for public policy and external affairs for Verizon's Southeast region; formerly acting senior vice president for state public policy and external affairs for Verizon for 16 Western states.

M-tron Industries, Inc.—COR VAN DER HEUVEL to European marketing manager; formerly European marketing manager at Champion Technologies, Inc.

Silicon Laboratories—SHANNON PLEASANT to director of corporate communications; formerly director of corporate communications at General Bandwidth Corp.

Palomar Technologies—DR. VENKAT SHASTRI to vice president of engineering; formerly senior director for engineering and product development at KLA-Tencor.

Andrew Corp.—RALPH E. FAISON to president and CEO; formerly president and COO.

Raytheon Co.—EDWARD S. PLINER to senior vice president and CFO; formerly vice president and corporate controller.

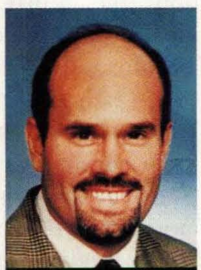
BAE SYSTEMS North America—RICHARD ASHOOH to vice president of legislative affairs; formerly vice president for public affairs with BAE SYSTEMS' Information and Electronic Warfare Systems business unit.

Enthone, Inc.—EDWARD KUDRAK to materials laboratory manager; formerly director of technology and technical service for the former Electroplating Chemicals & Services (EC&S) division of Lucent Technologies. Also, DR. IGOR S. ZAVARINE to senior research scientist; formerly R&D principal investigator and a member of the technical staff with the former Electroplating Chemicals & Services division of Lucent Technologies.

LeCroy Corp.—SCOTT D. KANTOR to vice president for finance and CFO; formerly vice president and corporate controller.

Spectrum Control—PAUL LEO to director of new business development for the Spectrum FSY Microwave line of products; formerly director of new business development at K&L Microwave.

LEO



KRAWIEC

StratEdge—CASEY KRAWIEC to senior account manager; formerly offshore sales manager and sales engineer at Kyocera America.

California Eastern Laboratories—PAUL MINTON to vice president for corporate development; formerly senior consultant with the Center for Simplified Strategic Planning. MRF

▸SHORT COURSES

Converging Voice and Data Networks
March 3-4 (Boston, MA)
March 10-11 (San Jose, CA)
March 24-25 (Dallas, TX)
Global Knowledge
9000 Regency Pkwy., Suite 500
Cary, NC 27511
(800) COURSES, FAX: (919) 461-8646
Internet: www.globalknowledge.com
Keyword: CONVERGENCE

Voice over IP
March 5-7 (Boston, MA)
March 12-14 (San Jose, CA)
March 26-28 (Dallas, TX)
Global Knowledge
9000 Regency Pkwy., Suite 500
Cary, NC 27511
(800) COURSES, FAX: (919) 461-8646
Internet: www.globalknowledge.com
Keyword: VOIP

Applied Technology Institute (ATI) Short Courses
Radar Systems Design and Engineering
March 3-6 (College Park, MD)
Holiday Inn
For further information, contact:
Applied Technology Institute (ATI)
12960 Linden Church Rd.
Clarksville, MD 21029
(888) 501-2100, FAX: (410) 531-1013
e-mail: ati@ATIcourses.com
Internet: www.aticourses.com

R.A. Wood Short Courses
Wireless Engineering
March 10-14 (Arlington, VA)
April 7-11 (Cape May, NJ)
May 12-16 (Cincinnati, OH)
Introductory RF and Microwaves
March 20-21 (Arlington, VA)
May 1-2 (Cincinnati, OH)
RF and Microwave Receiver Design
March 24-26 (Arlington, VA)
May 5-7 (Cincinnati, OH)
RF Power Amps, Classes A-S: How the Circuits Operate, How to Design Them, & When to Use Each
February 27-28 (Cocoa Beach, FL)
March 18-19 (Arlington, VA)
April 29-30 (Cape May, NJ)
May 8-9 (Cincinnati, OH)
R.A. Wood Associates
1001 Broad St., Suite 450
Utica, NY 13501
(315) 735-4217, FAX: (315) 735-4328
e-mail: rawood@rawood.com
Internet: www.rawood.com

▸MEETINGS

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Analyzing EM Scattering By Rotating Helicopter Blades

ROTATING HELICOPTER BLADES have been the subjects of number electromagnetic (EM) studies in order to better understand their radar cross sections (RCSs). Although not a trivial analysis, Philippe Pouliguen and associates from the Centre d'Electronique de l'ARmement (CELAR), Division GEOS (Bruz, France) have discovered a method based on the application of physical optics (PO) and the method of equivalent currents that can analyze the field effects of such moving objects through a quasi-stationary approach. Analyzed signals consist of the incident wave and a series of harmonics arising from the amplitude and phase modulations of the scattered signal. The harmonics are a function of the number of blades the the angular rotational frequency of the blades. Calculations can be parameterized as a function of the locations of the radar transmitter and receiver relative to the center of the rotor. See "Calculation and Analysis of Electromagnetic Scattering by Helicopter Rotating Blades," *IEEE Transactions on Antennas and Propagation,* October 2002, Vol. 50, No. 10, p. 1396.

Method Of Moments Aids Full-Wave Analysis Of Antenna Wire Models

WIRE MODELS OF ANTENNAS have been used in telecommunications studies for some time. Tie Jun Cui and fellow researchers from the Center for Computational Electromagnetics of the University of Illinois (Urbana, IL) show good results for a wire model in which current is assumed to flow along the axis and testing is performed on the whole surface. Coupled with the method of moments (MOM), the new model helps simplify analysis of complex designs. See "Full-Wave Analysis of Complicated Transmission-Line Circuits Using Wire Models," *IEEE Transactions on Antennas and Propagation,* October 2002, Vol. 50, No. 10, p. 1350.

TIA Array Handles 12 Parallel Communications Channels At 10 Gb/s

INCREASED DEMAND FOR WIDEBAND communications channels has sparked the development of a novel transimpedance-amplifier (TIA) array capable of handling 12 parallel optical channels at 10 Gb/s each. The total bandwidth of 120 Gb/s is the highest value reported for a single-chip amplifier array. In work reported by Alexander Schild, Hans-Martin Rein, and associates from Ruhr-University Bochum (Bochum, Germany), a system was assembled consisting of 12 vertical-cavity surface-emitting lasers (VCSELs) driven by an array of laser drivers. A total of 12 high-gain TIAs were placed at the end of a fiber-ribbon cable with 12 parallel fibers to achieve the total bandwidth. The TIA amplifier array was fabricated with a high-yield, 0.35-μm silicon germanium (SiGe) production bipolar technology using a single +5 or –5 VDC supply voltage and differential outputs. The SiGe process is reported to achieve transition frequencies as high as 70 to 75 GHz. By designing the chip to minimize power consumption, the total current per amplifier channel is only 23.3 mA, for a total chip power consumption of 1.4 W. Measurements at 10 Gb/s show the TIA array to achieve clean eye diagrams for a single channel when evaluated with a peak-to-peak voltage swing of 500 mV. In order to determine whether the TIA array had enough margin for error-correction bits, the device was evaluated at 12.5 Gb/s with the test results revealing low jitter and clear eye diagrams. See "High-gain SiGe Transimpedance Amplifier Array for 1 12 x 10 Gb/s Parallel Optical-Fiber Link," *IEEE Journal of Solid-State Circuits*, January 2003, Vol. 38, No. 1, p. 4.

Full-CMOS 2-GHz Transmitter And Receiver Aid WCDMA Systems

ALTHOUGH ONCE CONSIDERED TOO SLOW, CMOS technology has made great strides in recent years in achieving frequencies comparable to silicon bipolar and GaAs processes. To prove the point, Kang-Yoon Lee and associates from the Inter-University Semiconductor Research Center of Seoul National University (Seoul, South Korea) have developed an all-CMOS transmitter and receiver for 2-GHz wideband code-division-multiple-access (WCDMA) applications. The direct-conversion architecture is combined with a multiphase sampling fractional-N prescaler and digital gain control for high performance. Implemented in 0.35-μm CMOS, the power-efficient transmitter achieves +6 dBm maximum output power with a 50-dB dynamic range and 38-dB adjacent-channel power rejection (ACPR) ratio at 1.92 MHz, while the receiver boasts sensitivity of –115.4 dBm with a 4-dB noise figure and 80-dB dynamic range. See "Full-CMOS 2-GHz WCDMA Direct Conversion Transmitter and Receiver," *IEEE Journal of Solid-State Circuits*, January 2003, Vol. 38, No. 1, p. 43.

Electromagnetic Analysis Speeds RFID Design

Modeling and analysis performed with a suite of planar three-dimensional electromagnetic (EM) simulation tools simplifies the design of RFID tags.

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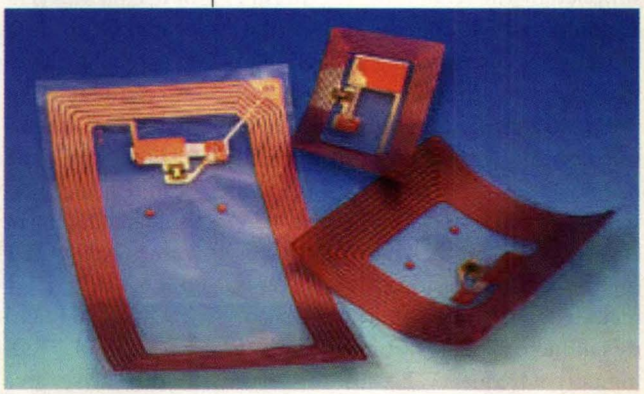
Sonnet Software, Inc., 1020 Seventh North St., Suite 210, Liverpool, NY 13088; (877) 776-6638, (315) 453-3096, FAX: (315) 451-1694, e-mail: info@sonnetusa.com, Internet: www.sonnetusa.com.

Radio-frequency identification (RFID) is one of the fast-growing wireless market segments. Strong competition among RFID suppliers, however, requires fast product design times and rapid time to market. Fortunately, fast and accurate electromagnetic (EM) analysis and simulation tools can shave design time. What follows is a demonstration of how software tools from Sonnet Software (Liverpool, NY) can quickly and accurately evaluate a 13.56-MHz inductor design for an RFID product.

The accuracy of the software is based on the use of Fast Fourier Transform (FFT) techniques while the processing speed is the result of Adaptive Band Synthesis (ABS) interpolation. In addition, the software's automated features, including parameterization and optimization, allow the designer to evaluate a large number of alternatives in a short period of time. As wireless markets consolidate, efficient use of effective computer-aided-engineering (CAE) tools, such as the Sonnet EM software, is a key to survival.

The EM software uses Maxwell's equations to analyze planar circuits. A user specifies a design geometry as input. Geometries can be drawn, or they can be imported as files in GDSII or AutoCAD format or from other simulation/analysis tools from Agilent Technologies (Santa Rosa, CA), Ansoft (Pittsburgh, PA), Applied Wave Research (El Segundo, CA), Cadence Design Systems (San Jose, CA), or Mentor Graphics (Beaverton, OR). Then, based directly on Maxwell's equations, Sonnet solves for the S-parameters or Z-parameters of the structure. Since the calculations are based on FFTs, they are



1. These RFID tags (courtesy of Texas Instruments, Dallas, TX) can be laminated into tags, cards, and almost any item that must be tracked and identified electronically.

2. The Sonnet suite was used to capture a typical six-turn RFID tag coil.

extremely accurate. There is no numerical integration used at any time. The EM software analyzes a circuit contained in a rectangular shielding box. The top cover can be removed to allow radiation. Sonnet works well with nearly any number of substrate layers and the layers can be nearly any thickness, all with full accuracy and speed.

RFID systems have been designed at a variety of different frequencies, although 13.56 MHz is one of the more popular RFID frequencies. In operation, the tag coil **(Fig. 1)** draws power from the RF energy radiated by a reader coil. Then the RFID tag's integrated circuit (IC) alternately resonates and detunes the tag coil, thus modulating the tightly coupled reader coil with data stored in the tag IC. Unlike bar codes, which must be visible to be read, RFID tags can be read when hidden, even when used in conditions of snow, rain, or excessive heat. Since the power is supplied by the reader, the tag doesn't require a battery. The tags are extremely durable, often lasting longer than the equipment that they tag.

Figure 2 shows a typical RFID inductor modeled with Sonnet.[1] It is a planar inductor with six turns, each 0.5 mm wide and separated by 0.5 mm. The coil is 78 × 41 mm. The input port is on the left-hand side. Metal loss is included in the planar EM analysis of this inductor. Analysis time is about 1 minute per frequency. Because this analysis uses the Sonnet ABS interpolation, accurate data at 300 frequencies is calculated from EM analysis at only four frequencies, thus requiring only four minutes for a full analysis.

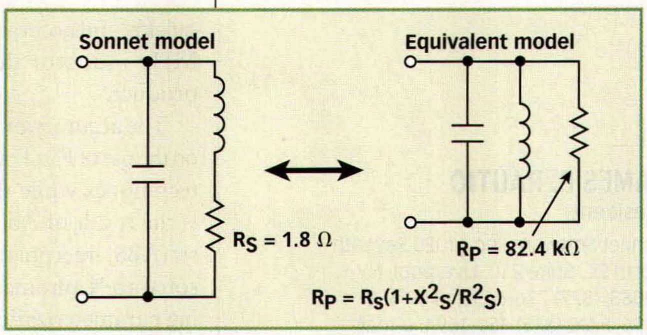
A lumped equivalent-circuit can be generated by using the Sonnet option "Analysis → Optional files → Add SPICE."[2] The result of this operation is a SPICE-format file. To perform an analysis on the equivalent circuit, two frequencies are required. For the purpose of checking the SPICE results, it is a good practice to create two SPICE files for comparison. For this example, the first SPICE file was generated from data at 12.1 and 13.3 MHz, with the resulting equivalent-circuit element values being C1 1 0 = 1.09 pF, L1 1 2 = 4523 nH, and RL1 2 0 = 1.71 Ω.

The second SPICE file was generated from data at the slightly higher frequencies of 13.3 and 14.65 MHz, with the resulting equivalent-circuit element values being C1 1 0 = 1.11 pF, L1 1 2 = 4521 nH, and RL1 2 0 = 1.77 Ω. Both analyses give almost exactly the same answer, implying that the SPICE model is an accurate representation of this inductor. With this confidence, the SPICE model can now be used in an RFID circuit design.

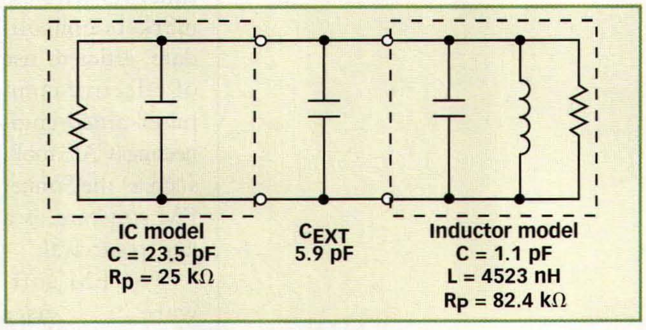
The Sonnet SPICE model of the inductor **(Fig. 3, left)** includes a resistor in series with the inductor. For some calculations, it is also desirable to know the equivalent parallel resistance, which can be easily calculated using the equation in Fig. 3. For a series resistance of 1.8 Ω, the equivalent parallel resistance is 82.4 kΩ. From the Sonnet generated SPICE model, the capacitance is 1.1 pF and the inductance is 4523 nH.

The RFID IC intended for the RFID circuit design has 23.5 pF total internal capacitance. The inductor calculated by the Sonnet SPICE model already has 1.1 pF of capacitance. In order to make a 4523-nH coil resonant at 13.56 MHz, a total of 30.5 pF capacitance is needed. As a result, it is necessary to add a 5.9-pF external capacitor to tune the inductor to 13.56 MHz when it is connected to the RFID IC.

A schematic diagram of the entire



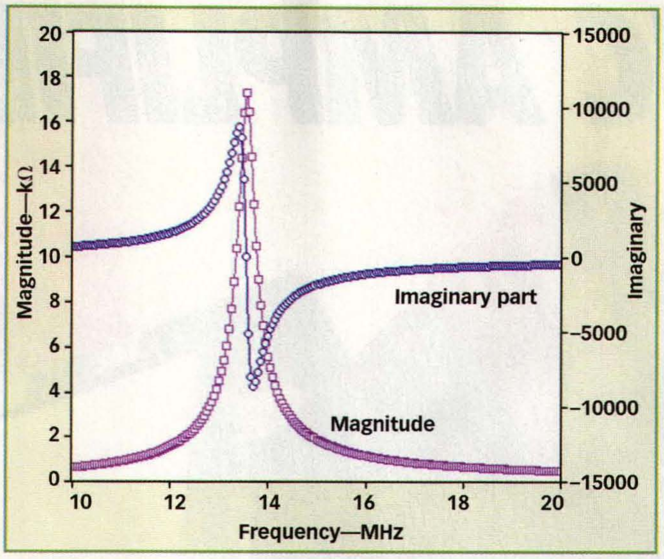
3. This SPICE lumped-element circuit (left) was synthesized by Sonnet. An equivalent circuit (right) of the SPICE model (right) can be useful for some calculations.



4. This equivalent circuit represents the entire tag coil circuit, including the RFID integrated circuit (IC), the external resonating capacitor, and the tag coil.

RFID tag coil circuitry is shown in **Fig. 4**, with the RFID IC on the left. The IC's manufacturer specifies both an internal capacitance and resistance. The external 5.9-pF capacitor is in the center. The inductor model generated by Sonnet is on the right.

It is useful to calculate the total impedance of the resonant circuit at the resonant frequency. This is simply the parallel combination of the RFID IC internal resistance of 25 kΩ with the 82.4 kΩ equivalent parallel resistance of the coil, which yields a total resistance of about 19 kΩ. This is the impedance that the RFID IC sees at resonance.



5. Analysis of the complete RFID circuit shows the expected high impedance (magnitude) at the 13.56-MHz resonant frequency where the imaginary part of the impedance goes to zero.

The RFID circuit model represented in Fig. 4 is easily analyzed using any nodal circuit simulator, or with the simple nodal analysis tool available with the Sonnet software suite. The Sonnet netlist[2] for this circuit is as follows:

CAP 1 C = 23.5 pF (RFID IC model);
RES 1 R = 25000 Ω (RFID IC model);
CAP 1 C = 5.9 pF (external capacitor); and
PRJ 1 0 RFID_1.son Use sweep from RFID_1.son
DEF1P 1 Net Main

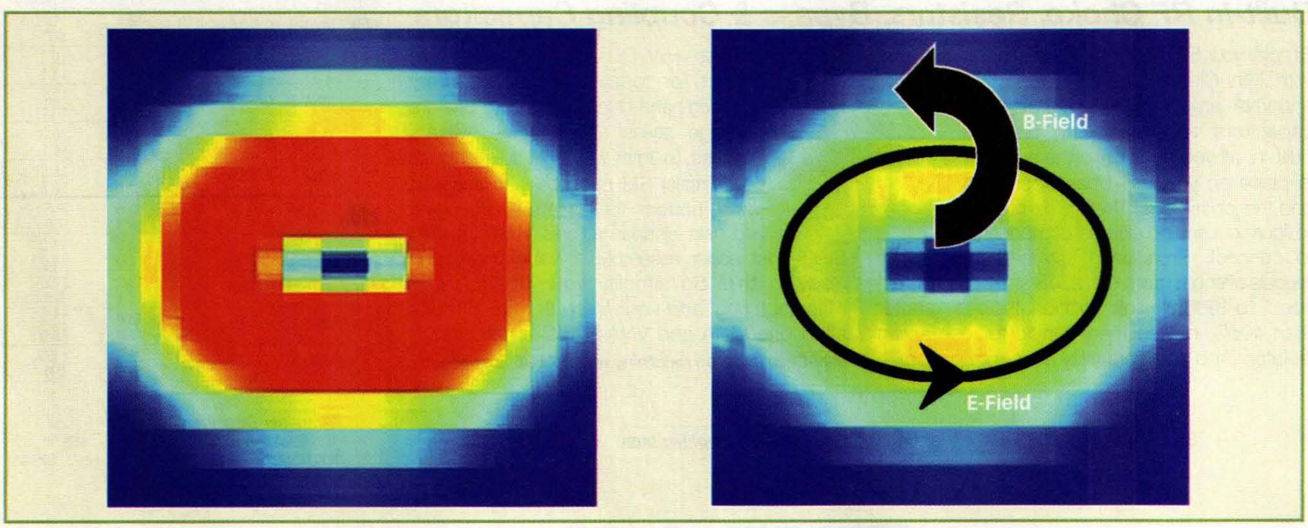
The fourth (PRJ) line is special. If needed, this line automatically launches a Sonnet EM analysis of the coil. If there have been no changes made in the coil layout since the last analysis, then the previous data is immediately used allowing very rapid trade-off analyses of the rest of the circuit.

The results of the planar EM analysis of the RFID circuit are shown in **Fig. 5**, where the input impedance (Z-parameter) is plotted. The magnitude of the impedance (close to 19 kΩ) can be seen at the 13.56-MHz resonance. The resonance occurs at the frequency for which the imaginary part of the input impedance is zero. (It should be noted that the entire analysis to this point can be performed using a free copy of SonnetLite software.[3] SonnetLite software is identical to the full-featured, commercial version of Sonnet software, but is limited in the size of the problem that it can handle.)

The inductor's fields are viewed by means of a "sense layer."[4] The Sonnet EM software suite only allows viewing of electric fields that are parallel, or tangential, to the surface of the substrate. Using this "sense layer" feature, strong E-fields are revealed in red while the blue color indicates an absence of electric-field (E-field) energy.

The left-hand side of **Fig. 6** shows the tangential E-field 25 mm above the inductor. The tangential E-field is strongest near the windings of the coil. The same is true 35 mm above the inductor (right-hand side of Fig. 6), although the fields are not as strong at this distance above the inductor.

Sonnet software does not plot the magnetic (B) field directly, although it is easy to see what the B-field does. From Maxwell's equations, it is known that the B-field "curls" around the E-field, in the manner that a B-field curls around a current-carrying wire. This is shown



6. Sonnet was used to calculate the tangential E-field of the RFID circuit at 25 mm (left) and 35 mm (right) above the coil. Although the software does not directly plot the B-field pattern, the graphic illustrates how the B-field would curl around the E-field.

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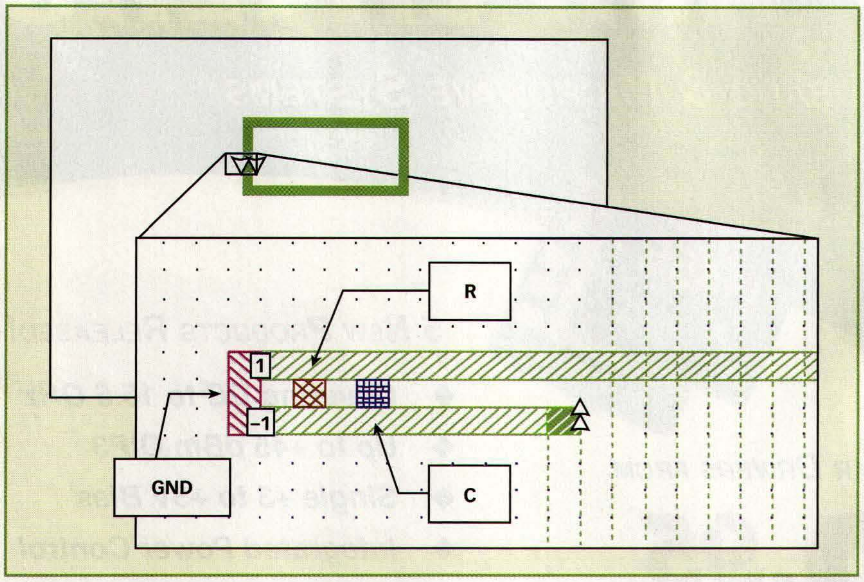


7. Faster analysis time can be achieved by using an internal port. Lumped components can be included by modifying the surface impedances of small squares of resistive metal.

on the right-hand side of Fig. 6. Thus, by looking at the two-dimensional (2D) tangential E-field, it is possible to visualize the full three-dimensional (3D) B-field curling around the inductor.

The port used for all analyses so far has been at the far left-hand edge of the substrate. This box edge represents a side of a perfectly conducting box that contains the entire circuit. The box sidewall is a perfect ground reference and results in the highest possible analysis accuracy. As described in the Sonnet software documentation, the Sonnet de-embedding function can shift the reference plane from the actual port location at the box sidewall to the inductor. This removes the electrical effects of the long transmission line between the port and the inductor from all calculations.

A slightly less accurate port can also be used for the analysis,[5] using a port close to the inductor **(Fig. 7)**. In this analysis, a small resistor, R, has also been added. This resistor is a patch of metal with resistance is set to 25 kΩ/square. One square of this resistance exactly models the internal resistance of the RFID IC. The square marked "C" has a metal with surface reactance set to –399.5 Ω/square. One square of this special reactive metal exactly models the 23.5-pF RFID IC internal capacitance and the 5.9-pF external capacitance at 13.56 MHz. Note that this reactance stays constant at all frequencies. Thus, it is exactly accurate only near the resonant frequency which, for the case of this analysis, does not pose a problem. The result using this port is almost the same as before.

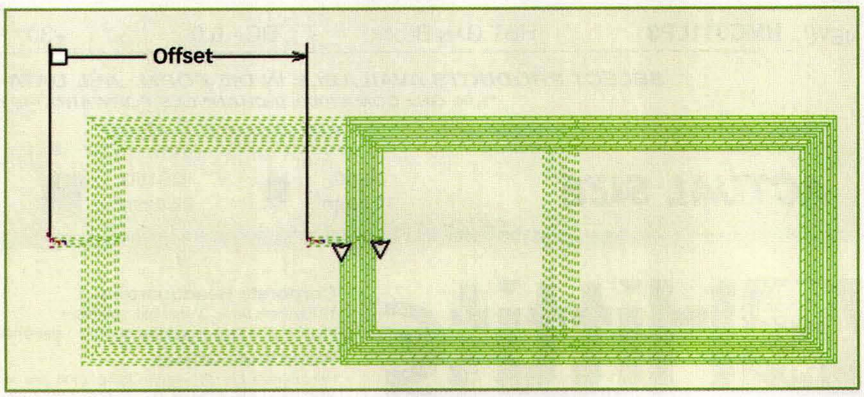
The software allows special metal types to be added by following the command sequence "Circuit → Metal Types → Add." The capacitor in this analysis is a "General" metal type with all values equal to zero except for XDC. Since there is no longer any transmission line to remove, and the port discontinuity is very small, the de-embedding function can be turned off (using the sequence Analysis → Setup → Advanced → uncheck de-embed).

How does coupling vary with offset between the reader coil and the tag coil? To check this,[6] a second inductor was added 50 mm above the first one **(Fig. 8)**, and the box containing the circuit was made larger. This is important in order to prevent the inductor from getting too close to the box sidewalls.

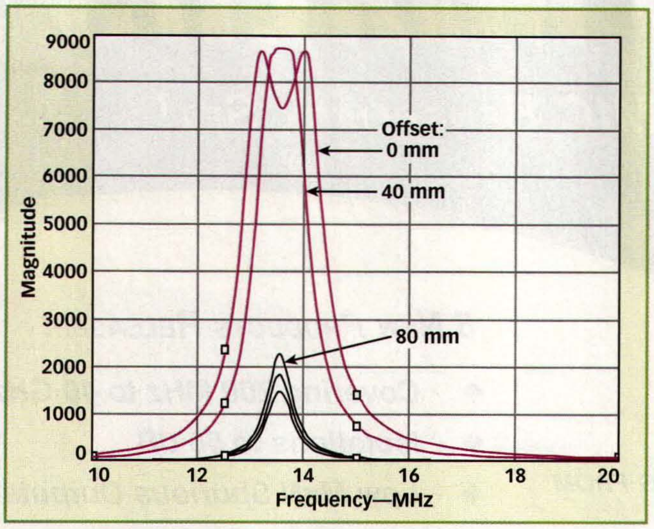
For the analysis, the offset was varied from 0 to 160 mm in 40-mm steps. The reader inductor is shown in Fig. 8 with an offset of 40 mm. Sonnet was set up to automatically calculate a full frequency sweep for each of the five reader coil positions. Each frequency sweep generates about 300 data points. Because the Sonnet ABS interpolation was used, analysis was only needed at only four frequencies to generate data at all 300 frequencies.

After completing the Sonnet analysis, it is possible to determine how much voltage is generated at the tag coil (port 1) when current enters the reader coil (port 2), which is simply the value of Z_{12}. For example, if Z_{12} is 9000 Ω, then 1 mA into the reader coil generates 9 V on the tag coil port. Since the Sonnet software layout includes the internal resistance of the RFID IC, a full 9 V will appear at the RFID IC to be used for operation.

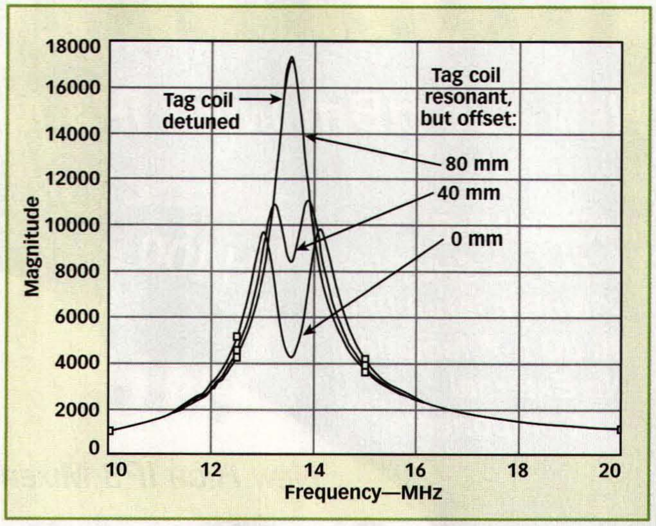
Figure 9 shows that for both 0- and 40-mm offsets, the value of Z_{12} is just under 9000 Ω. Thus, the RFID IC will have just under 9 V to operate for every 1 mA of current going into the reader coil.



8. Two RFID coils can be repeatedly analyzed as a function of their offset. The tag coil is represented by the dashed lines while the reader is shown by the solid lines.



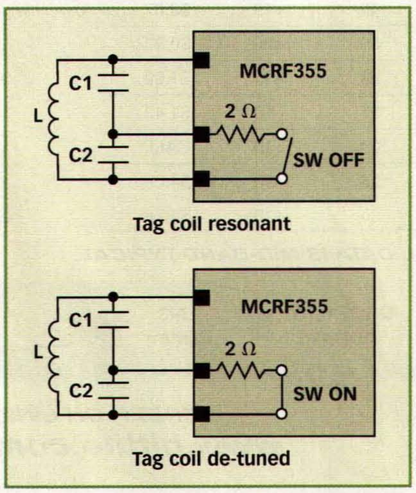
9. Coupling between two RFID coils is strong until the offset exceeds 80 mm.



11. No coupling occurs between coils when the tag coil is detuned or at large offsets (80 mm or more) from the reader coil.

The value of Z_{12} drops off quickly for offsets of 80 mm or more. At this distance, the reader coil has just passed beyond the edge of the tag coil. For large offsets, the tag coil gets only about 2 V for every 1 mA flowing into the reader coil.

When the tag coil gets enough power, it operates by repeatedly tuning and detuning the coil to resonance at 13.56 MHz. **Figure 10** (from ref. 7) shows an example from Microchip. When the tag resonant circuit is detuned, the tag coil has no effect on the impedance of the reader coil. When the tag coil is resonant, it couples strongly to the reader coil and changes the reader coil impedance. It is this change in impedance that is read by the reader. Most RFIC chips operate by shorting out the entire inductor. The approach shown here (patented by Checkpoint Systems) simply detunes the circuit allowing a higher data rate.



10. The RFID IC operates by alternately tuning (top) and de-tuning (bottom) the tag coil for resonance at 13.56 MHz.

When the tag coil is resonant, the input impedance of the reader coil is Z_{22}. When the tag coil is detuned, the tag coil has no effect on the reader coil. In this case, the reader coil impedance is the same as if there is no tag coil present. In **Fig. 11**, this difference can be seen directly. By sensing this change in coil impedance, the reader can read the information sent by the tag coil.

When there is a large offset between the reader coil and tag coil, the tag coil has no effect on the reader coil. The reader coil has an input impedance of about 18000 Ω. When the tag coil is detuned by the RFID IC, the tag coil will also have no effect on the reader coil. In this case, the reader coil input impedance will also be 18000 Ω, regardless of where the tag coil is located.

When there is 0 mm offset between the tag coil and the reader coil, the resonant tag coil couples strongly to the reader coil. The reader coil input impedance then drops to about 4000 Ω. If the offset is 40 mm, the resonant tag coil changes the reader coil input impedance to about 8000 Ω. At offsets of 80 mm and more, there is little change. At 80 mm offset, the reader coil has moved so there is no overlap with the tag coil. There is also almost no coupling. Repeating this analysis using a reader coil two times bigger also shows that there is little coupling when there is little overlap between the coils.

In conclusion, Sonnet's EM and nodal analyses can be used to easily analyze RFID coils. The software helps precisely calculate the additional capacitance required when using a particular RFID IC. The analysis included metal loss and evaluated how the coupling between the RFID reader and tag change as the reader coil is moved. This study also demonstrated the use of Sonnet's new ABS interpolation, by allowing the analysis at just a few frequencies to generate equivalent results for analyses performed with hundreds of frequencies. In fact, all the EM analyses in this paper were performed with only four analyses per complete frequency sweep; analysis of the first coil configuration was performed with SonnetLite, a software package available free of charge from Sonnet Software. MRF

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3. SonnetLite can be downloaded from http://www.sonnetusa.com.
4. Sonnet User's Guide, Vol. 1, Chap. 21, the relevant circuit is represented in files RFID_sense_25.son and RFID_sense_35.son.
5. This is a reference to the file named RFID_2.son.
6. This is a reference to the file named RFID_3.son.
7. Microchip (www.microchip.com), "microID™ 13.56 MHz RFID System Design Guide."

Software Shaves Time Off Filter Synthesis

The latest version of a filter synthesis program for the personal computer supports the creation of microstrip, stripline, lumped-element, and waveguide filters.

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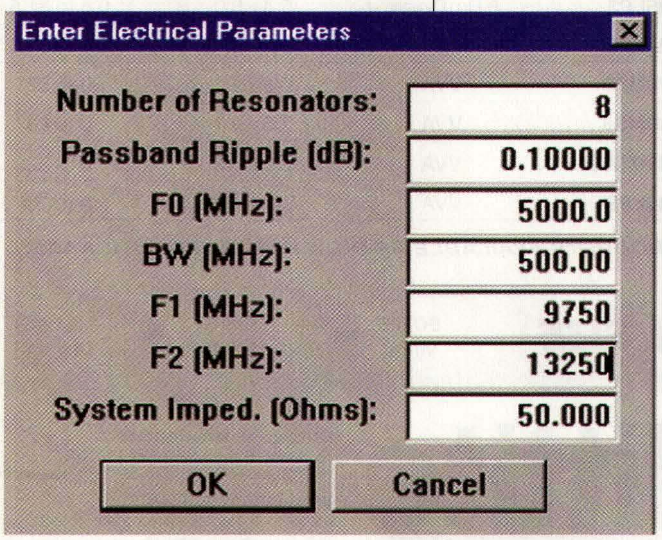
Filter designers have a wide choice of commercial software design tools at their disposal. But the latest version (Version 3.0) of the MMICAD filter synthesis software suite from Optotek Ltd. (Kanata, Ontario, Canada) now includes user-defined physical surroundings as an integral part of the synthesis operation. The software synthesis tool is actually a set of 35 dedicated programs for the design of microstrip, lumped element, stripline, and waveguide filters. The design interface and common menu format seamlessly integrates with the MMICAD linear simulator and physical layout in a user-friendly design environment. A design example of a parallel coupled bandpass filter will be illustrated in this article.

The parallel coupled-line bandpass filter is one of the more popular microwave-filter designs.[1] It is suitable for implementation in microstrip and surface-mount construction. However, there are practical limitations to its design. Design bandwidths are limited to about 20 or 30 percent around the center frequency due to decreasing input coupling gap that is a function of increasing bandwidth and decreasing passband ripple.



1. This dialog box is used for entering the electrical parameters for the example filter design.

There are also practical considerations in construction that includes the width of the housing, which should be kept less than one-half wavelength of the highest frequency in order to suppress the possibility of the TE_{01} waveguide mode propagation that can propagate energy around the filter

and limit the attainable stopband attenuation. The presence of a cover over the circuit can cause the passband frequency to be shifted, and this should be compensated for in the design synthesis. At higher frequencies, microstrip dispersion[2] must be accounted for if the passband is to be centered on the design frequency.

Other circuit discontinuities, such as microstrip metalizaztion,[3] and the capacitance at the ends of the coupled resonator lines,[2] must also be included in the filter synthesis. All of these factors should be included in the synthesis if multiple fabrication trials are to be minimized and possibly eliminated.

The interface to the synthesis software, the menu system, is organized and arranged to match the sequence of calculations a designer would normally follow. This gives the designer access to the intermediate steps in the calculations, and allows the designer the opportunity to control, interact, and optimize a design during the calculation process. For example, an electrical design may have been arrived at, and the microstrip dimensions can then be separately calculated and optimized by the designer varying the substrate dielectric constant and thickness, the metal thickness, the cover height, and the type of input coupling.

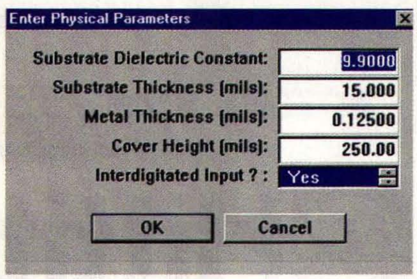
The requirement is for a filter that operates from 10.0 to 13.0 GHz with greater than 30-dB rejection at 9.0 and 14.0 GHz will be used as a design exam-

Microstrip filter
Parallel coupled-line bandpass

N = 8 A_m = 0.100 dB
F_1 = 9750.0 MHz F_2 = 13250.0 MHz
Z_0 = 50.0 Ω Q_u = 9999.0

Coupled line	Z_{0e} Ω	Z_{0o} Ω
1	76.95	23.05
2	48.33	22.61
3	45.10	25.84
4	44.59	26.35
5	44.48	26.46
6	44.59	26.35
7	45.10	25.84
8	48.33	22.61
9	76.95	23.05

2. This data window shows the calculated even- and odd-mode resonator impedances for the example filter.



3. Microstrip physical parameters for the filter example are entered into this dialog box.

Microstrip filter
Parallel coupled-line bandpass

N = 8 A_m = 0.100 dB
F_1 = 9750.0 MHz F_2 = 13250.0 MHz
Z_0 = 50.0 Ω Q_u = 225.0

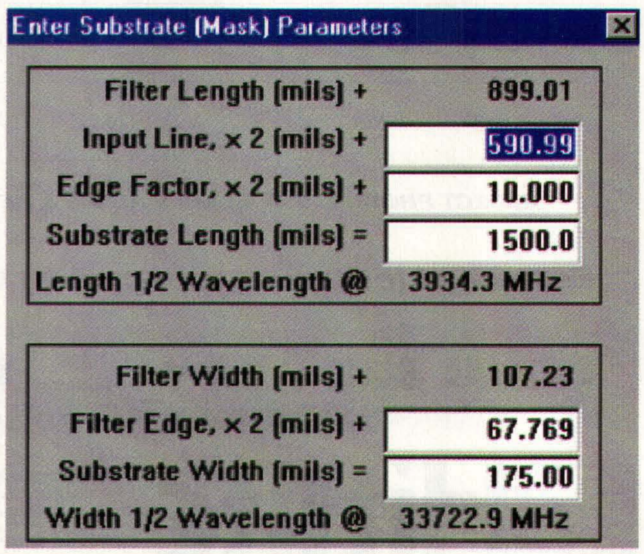
E_R = 9.90   H = 15.0 mils   T = 0.1 mils C_{VHT} = 250.0 mils

Even-mode Ω	Odd-mode Ω	Width mils	Length mils	Spacing mils
50.00		13.9		3.9
124.19	54.99	2.6	101.3	1.5
48.33	22.61	23.0	93.6	3.8
45.10	25.84	24.3	93.5	4.4
44.59	26.35	24.5	93.5	4.5
44.48	26.46	24.6	93.5	4.4
44.59	26.35	24.5	93.5	3.8
45.10	25.84	24.3	93.5	1.5
48.33	22.61	23.0	93.6	3.9
124.19	54.99	2.6	101.3	
50.00		13.9		

4. This data window shows the calculated microstrip dimensions for the example filter design.

ple. A filter with eight resonators and a passband ripple of 0.1 dB (return loss of 16.3 dB) will meet this requirement. The design bandwidth is set to 3.5 GHz centered at 11.5 GHz, which is an F1 of 9.75 GHz and F2 of 13.25 GHz, representing a fractional bandwidth of 30 percent.

Figure 1 shows the dialog window for entering electrical information for a desired filter, including the number of resonators, passband ripple, center frequency, bandwidth, rejection frequencies, and impedance. **Figure 2** shows the resulting calculated even- and odd-mode impedances for this parallel-coupled-line filter design. The synthesis software can also calculate the filter frequency response, including dissipative losses. The response calculation can be used to verify that the basic electrical design will meet a set of requirements, including the increased passband insertion loss at



5. This dialog box shows the layout dimensions for the example filter design, along with the calculated waveguide cutoff frequency.

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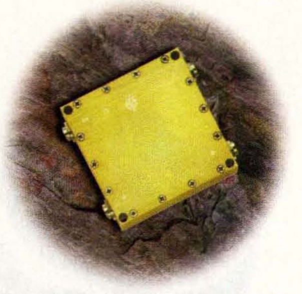

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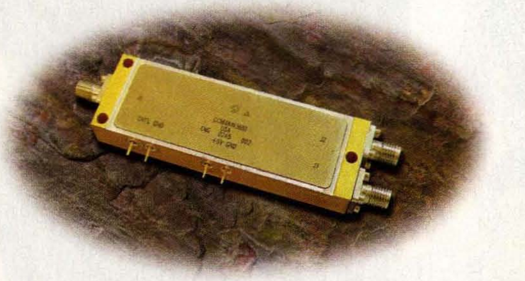

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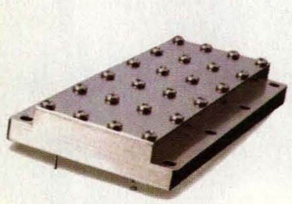

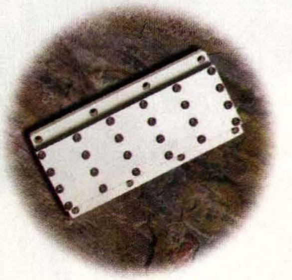

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the band edges due to dissipative losses. The calculated response for this design will be generated by Version 3.0 of the MMICAD linear circuit analysis program.[5]

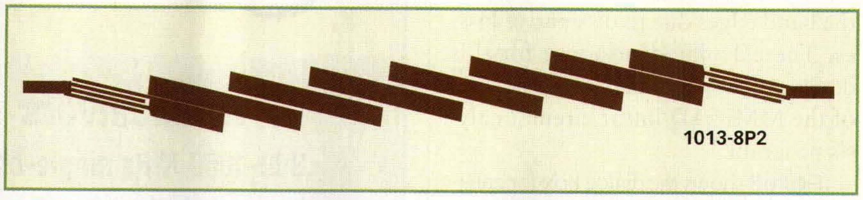
Figure 3 shows the dialog box for entering the physical parameters of substrate dielectric constant and thickness, metal thickness, and the type of input coupling. For this particular filter design, the substrate is 0.015-in.-thick alumina with 0.125-mil-thick thin-film metalization. The unloaded quality factor (Q) for this substrate obtained though experiment is about 225 at X-band.

Because of the tight input coupling required for this large bandwidth, interdigitated coupling lines were chosen for this filter. The filter's calculated dimensions are shown in **Fig. 4**. For noninterdigitated lines, the line width would be 11.1 mils although the line spacing would be only 0.4 mils, somewhat less practical to fabricate compared to the interdigitated design.

The parallel coupled-line bandpass filter is one of the more popular microwave-filter designs.

In **Fig. 5**, a dialog box is used for specifying the circuit layout and the circuit mask. There is an intermediate window (not shown) that allows choosing the arrangement of the circuit input and output lines. Here, input and output lines are selected on a common centerline. This produces the narrowest layout and substrate width, and maximizes the TE_{01} mode cutoff frequency for a metal enclosure. The calculated cutoff frequency is part of the dialog box and is 33.723 GHz for a substrate width of 175 mils. This width is chosen for mechanical packaging purposes. The overall length of the substrate is 1500 mils. Once all required values

have been entered into the dialog box, the software yields a circuit layout that can be written to a DXF file for direct generation of the photo mask. A photograph of the filter fabricated from this synthesized file is shown in **Fig. 6.**



6. This layout artwork offers a representation of the fabricated microstrip filter.

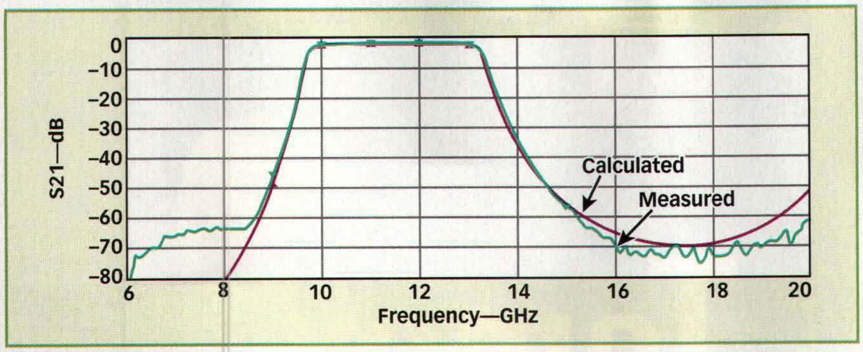
The filter-synthesis program generates a series of netlist files with the calculated nominal dimensions of the circuit for design verification, as well as files for analysis of changes in filter response with temperature, files for worst-case and yield analysis, and netlist files of circuit discontinuities to improve performance predictions.

Figure 7 gives the filter frequency response calculated by MMICAD over a wide frequency range. The calculation covers the frequency range of 6.0 to 20.0 GHz, and it shows the expected rejection of the filter. **Figure 8** gives the calculated response over a narrow band of 9.0 to 14.0 GHz, and this shows the expected passband insertion loss and return loss frequency response.

Fabricated Filter

The fabricated filter of Fig. 6 was evaluated with a vector network analyzer. Measurements of insertion loss, S_{21} in dB, and return loss, S_{11} in dB were saved in a file. This file, in turn, can be included in the MMICAD filter netlist for direct comparison of the measured and calculated responses. As a result, Fig. 7 shows that the measured rejection is close to the calculated performance. The rejection is better than 70 dB, and is the result of the narrow width of the filter housing suppressing the propagation of the TE_{01} waveguide mode. The rejection levels at 9.0 and 14.0 GHz are close to the calculated values. Figure 8 compares the measured and calculated passband responses. The measured response is close to the calculated, with the passband centered close to the design. The passband insertion loss response is also close to the calculated response, although three consequential conditions should be noted.

First, the pairs of interdigitated fingers can resonate in a quarter-wave-



7. The example filter's measured response compares closely with the response predicted by the MMICAD software.

length transverse-electromagnetic (TEM) mode and this condition causes a resonance suck-out in the passband. This was eliminated with bond wires that shorted the tips of the open circuit ends of the fingers. Second, the test fixture itself has a known insertion loss of 0.8 dB, due to SMA connector loss and transition to microstrip loss.

Consequently, a 0.8-dB attenuator is added to the filter circuit netlist to make the calculated losses match the measured. It is apparent that the measured rounding of the passband, the result of filter resonator dissipative losses, matches the calculated. The passband return loss is better than –15 dB, compared to the design value of –16.3 dB. And third, the measured results are for the first fabrication of this filter without any tuning or modifications.

The measured data for the fabricated filter is in excellent agreement with both the design goals and with the MMICAD simulation of the circuit synthesized dimensions. Only part of the reason for this success is the relatively tight tolerances that are possible with thin-film alumina microstrip. The excellent circuit performance is possible because the synthesis includes compensation of those circuit details that can alter and degrade the response. Furthermore, the MMICAD synthesis software facilitates design trade-offs as part of the synthesis process and it facilitates detailed circuit analysis by creating the necessary MMICAD netlists. MRF

ACKNOWLEDGMENT

Special thanks to US Microwaves (Santa Clara, CA, www.usmicrowaves.com) which provided foundry services for the filter produced for this article.

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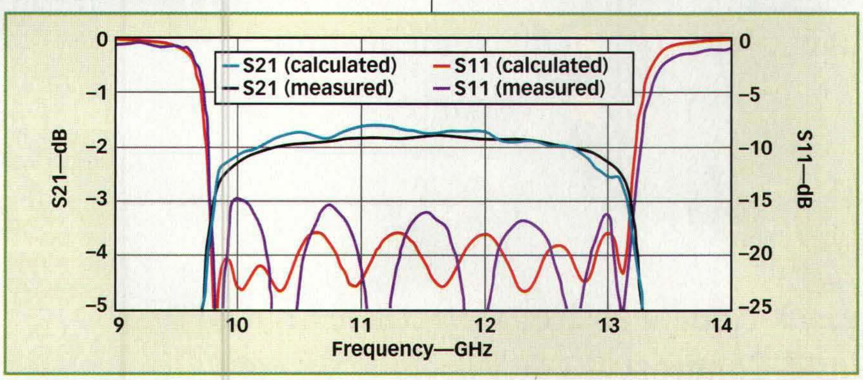
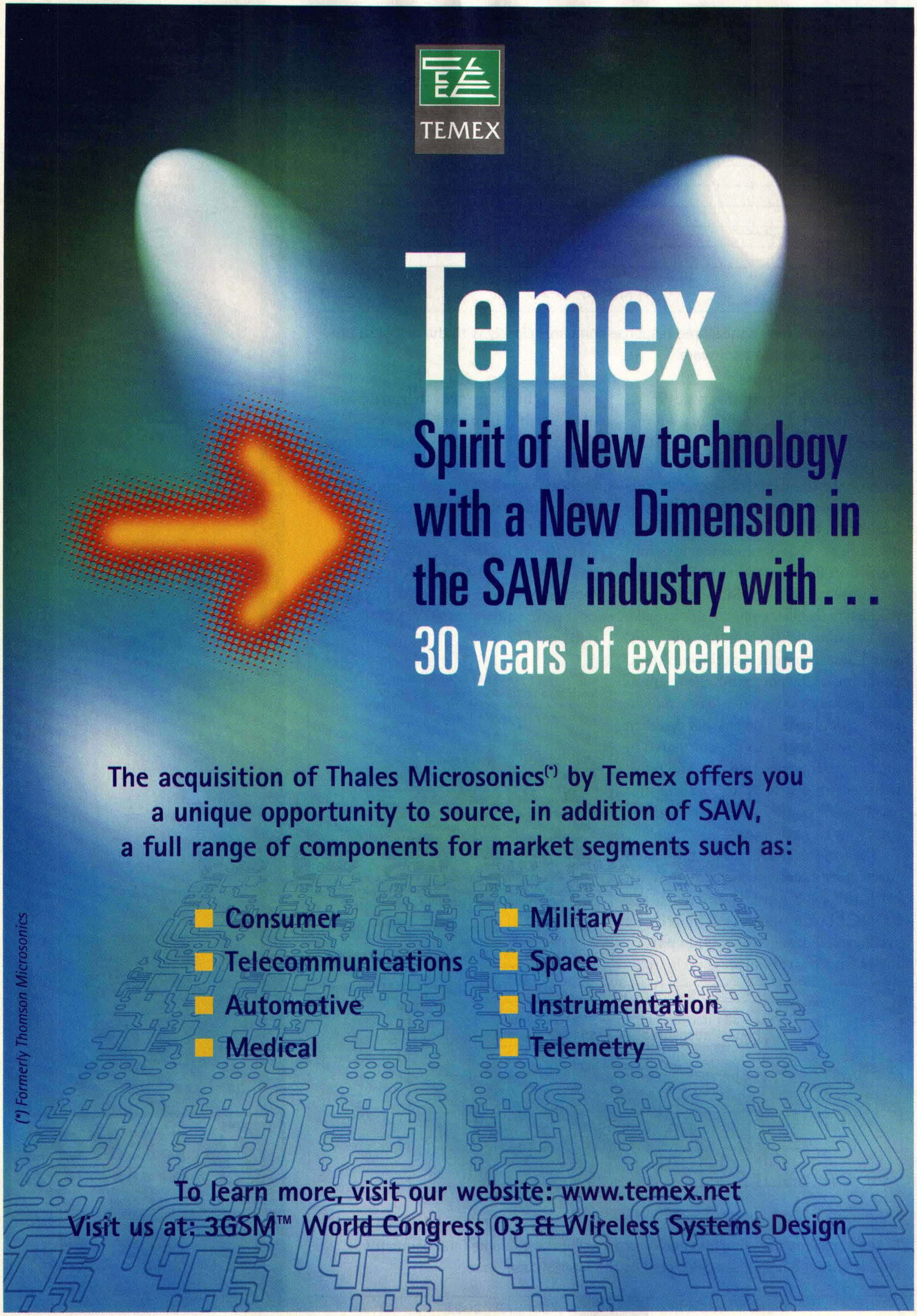


8. The measured insertion loss and return loss for the example filter compares closely with the responses calculated by the MMICAD software.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Advances in 3G Enhanced Technologies for Wireless Communications

JIANGZHOU WANG AND TUNG-SANG NG, EDS.

BROADBAND WIRELESS COMMUNICATIONS impacts the world on a daily basis and is the catalyst for many global research projects. *Advances in 3G Enhanced Technologies for Wireless Communications,* edited by Jiangzhou Wang and Tung-Sang Ng of the University of Hong Kong, is a compilation of technical papers by researchers and engineers from global telecommunications firms. The volume provides in-depth knowledge of the various technical disciplines for implementing third-generation (3G) wireless mobile-communications systems and offers information on enhanced techniques that will probably emerge as future standards in intermediate 3G (3.5G) or 3GPP2.

Chapter 1 covers wideband-code-division-multiple-access (WCDMA)-enhanced technologies, including physical channel and spreading-code assignment, transport-channel multiplexing, transport channel, asynchronous cell sites, and diversity. Chapter 2 analyzes downlink performance enhancements in CDMA cellular systems, including evaluation of WCDMA downlinks, assumptions in system evaluation, downlink capacities of WCDMA, optimum orthogonal code allocation in CDMA downlinks, and simulation conditions for evaluation of performance. Chapter 3 discusses the evolution of Global System for Mobile Communications/Enhanced Data rates for Global Evolution (GSM/EDGE) toward 3G mobile services, including coverage of radio-interface protocols, physical resources, logical channels, channel coding, and ciphering.

Chapter 4 focuses on the cdma2000 high-rate packet-data system, with explanations of IS-856 and IS-2000 system; link-budget analysis, assumptions, and calculations; and forward and reverse traffic-channel media-access controllers (MACs). Chapter 5 covers the peak-to-average ratio (PAR) of CDMA systems, including a general PAR definition, PAR analysis of CDMA signals, PAR for multicarrier CDMA systems, PAR control for CDMA signals, and a PAR reduction technique for multicarrier CDMA system. Chapter 6 discusses Internet Protocol (IP) mobility framework for supporting wireless and mobile Internet, with an examination of IP-mobility challenges, user identity, address management, security, and user privacy. The volume concludes with Chapter 7, on software radio, a prospective technology for future broadband communication systems. The chapter provides an overview of software radios, including a historical background; a frequency-domain illustration of receiver (Rx)-signal processing; single- and multistage decimation; and filter implementation. (2002, 354 pp., hardcover, ISBN: 1-58053-302-7, $99.00.) **Artech House, Inc. 685 Canton St., Norwood, MA 02062; (781) 769-9750, FAX: (781) 769-6334, e-mail: artech@artechhouse.com, Internet: www.artechhouse.com.**

Model MMIC Nichrome Resistors

This methodology guides engineers in the precise RF parameter extraction when developing models for monolithic-microwave-integrated-circuit (MMIC) nichrome resistors.

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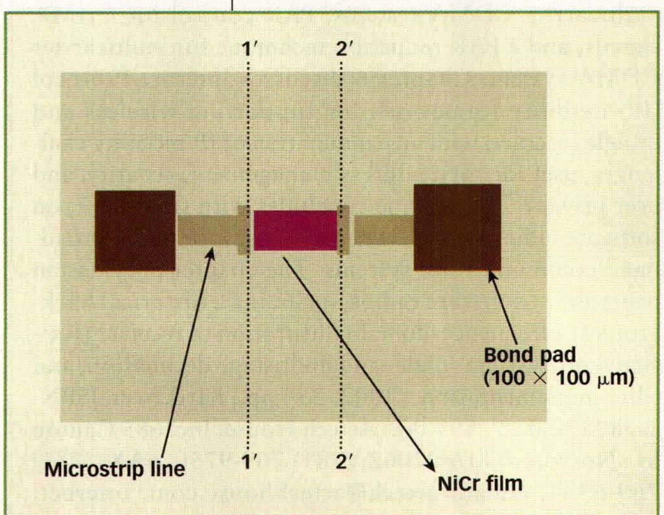
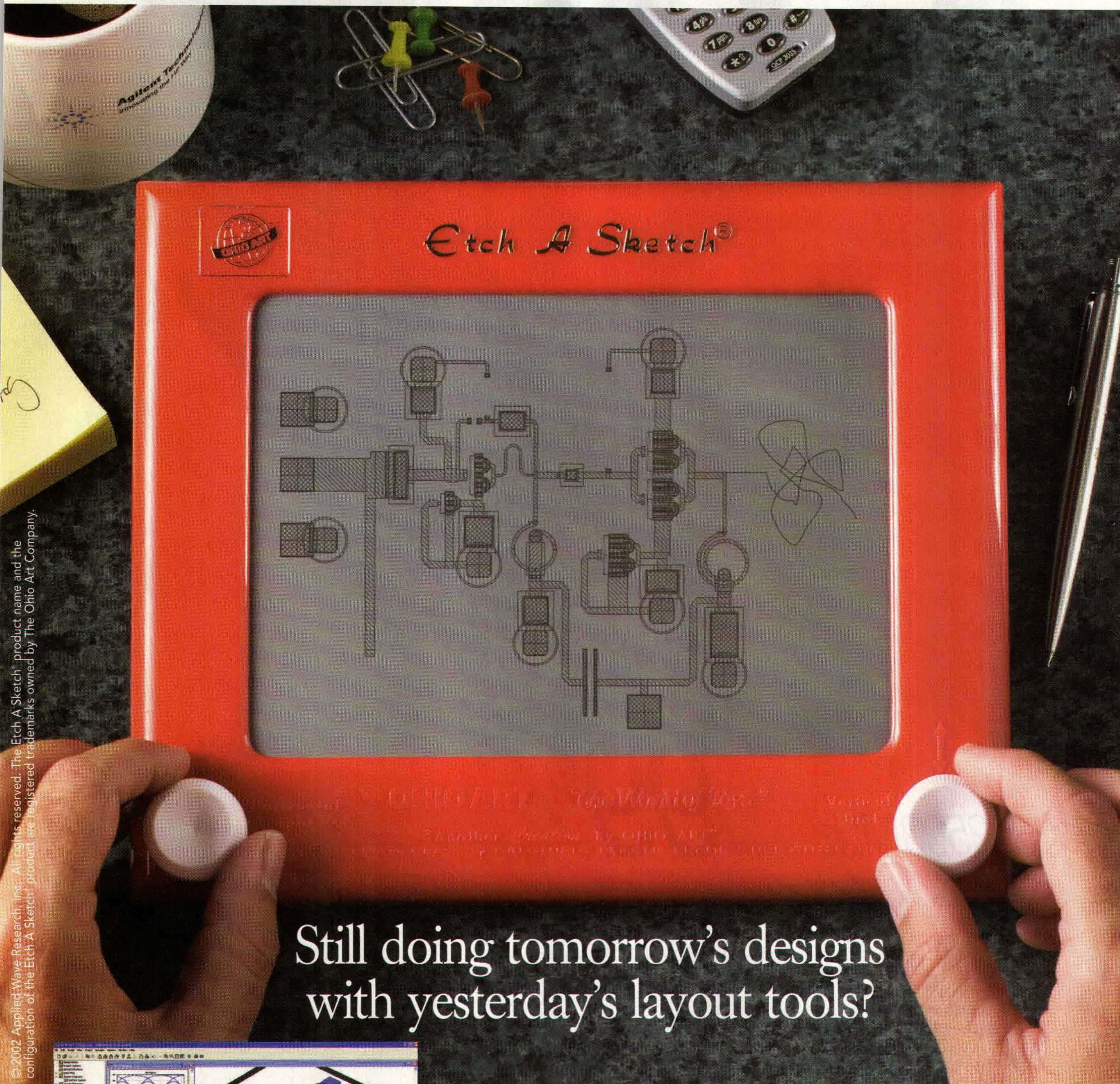
Nichrome resistors are commonly used as part of the process of fabricating monolithic microwave integrated circuits (MMICs). An effective MMIC model, however, must include an accurate model of a nichrome (NiCr) resistor. Fortunately, what follows is a methodology for the data-based parameter extraction required for developing an accurate NiCr resistor model. These resistors have been fabricated on gallium-arsenide (GaAs) semi-insulating substrates, and then are diced and bonded onto a coplanar-waveguide (CPW) test fixture so that two-port scattering (S) parameters can be measured over a wide band of frequencies. An algorithm based on the de-embedded S-parameters has been developed to extract the electrical parameters of an equivalent circuit for the NiCr resistor. The frequency-dependent model parameters have been extracted to 15 GHz for a large number of resistors of varying geometries and curve-fitted equations for the model parameters have been obtained. As will be shown, the model-predicted S-parameters agree closely with the measured results.

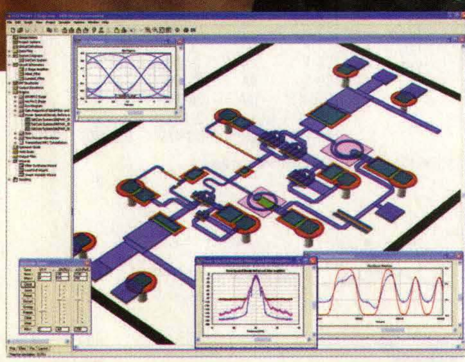
MMICs consist of planar integrated active and passive elements that determine the circuit operation. Passive elements are composed of lumped elements such as resistors, capacitors,



1. This is a top view of the NiCr resistor to be modeled.

AWR





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$$L_{BW} = (\mu_0 l / 2\pi)\left(\ln\left\{(2l/d) + \left[1 + (2l/d)^2\right]^{\frac{1}{2}}\right\} + (d/2l) - \left[1 + (d/2l)^2\right]^{\frac{1}{2}} + \mu r\delta \right) \quad (1)$$

$$C_{BP} = 5.6 \times 10^{-7} W^2 + 2.3 \times 10^{-4} W \text{ (in pF)} \quad (2)$$

and inductors and distributed elements such as transmission lines. In MMIC technology, the resistors are extensively used in feedback circuits, bias circuits, and as terminations. Two types of resistors are commonly used in MMIC fabrication, namely, thin films of lossy metals and lightly doped GaAs active layer (mesa resistors).[1] Metal thin-film resistors are more temperature stable and are used as precision resistors of low to moderate values. These are usually fabricated from TaN and NiCr although other metals may be used.[1,2] NiCr resistors have low thermal coefficient of resistance (TCR), small parasitic values, and are widely used in a variety of circuit designs [3,4]

The resistors in this research were grown in-house by means of RF sputtering. NiCr resistors have been grown on 200-μm semi-insulating GaAs substrates with 1.0-μm-thick polymide used as the passivating layer. The sheet resistance is typically about 40 Ω/square and the TCR is about 250×10^{-6}/°C. The resistor values selected for this work range from 5 Ω to 2 kΩ.

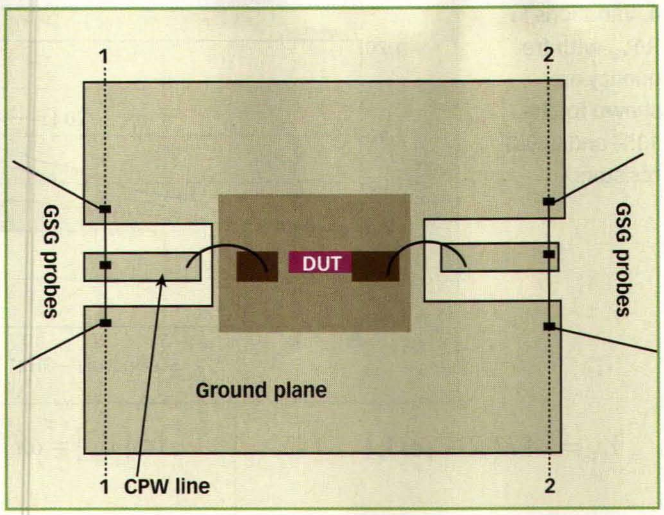
Figure 1 shows a top view of a typical NiCr resistor with input and output pads. For RF characterization of the diced resistors, the authors designed a CPW test card with 50-Ω input and output lines **(Fig. 2)**. The resistor chip is die bonded onto the ground plane of the card and the resistor terminals are wire bonded to the input/output (I/O) signal lines by means of 1-mil-diameter gold bond wires. The bonded chips are then characterized for small-signal S-parameters to 15 GHz using ground-signal-ground (G-S-G) wafer probes from Cascade Microtech (Beaverton, OR) and an 8510C microwave vector network analyzer (VNA) from Agilent Technologies (Santa Rosa, CA) in conjunction with the Cascade Microtech probe station.

The two-port S-parameters of the bonded resistor chips were measured at the CPW Test Card I/O planes 1 –1 and 2 –2 as shown in Fig. 2. Multiple-step de-embedding was carried out to extract the S-parameters at the resistor

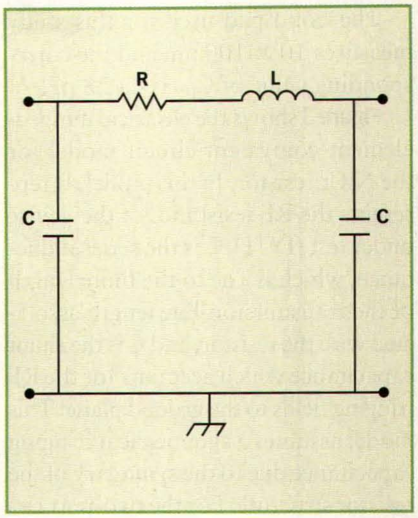
places 1′–1′ and 2′–2′ by using software from Agilent-EEsof (Santa Rosa, CA). Bond-wire and bond-pad models used in this analysis are given below.

The inductance of the bond wire can be calculated from the following expression:[5]

SEE EQ. 1 ON P. 79.



2. For test purposes, the NiCr resistor has been mounted on a coplanar-waveguide (CPW) test card.



3. This circuit portrays a lumped-element equivalent circuit of the NiCr resistor.

where:

d = the diameter of the gold wire and

l = the length.

For 1-mil-diameter bond wire, the value of L_{BW} comes out to be 0.7 nH/mm. The bond-pad capacitance can be obtained from the GEC-Marconi foundry model[6] using the expression:

SEE EQ. 2 ON P. 79.

where:

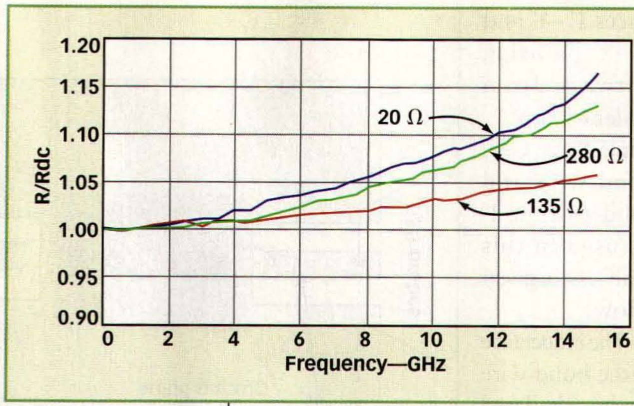
W = the dimension of the square bond pad (in μm)

The bond pad used for this study measures 10 × 100 µm and the corresponding value of C_{BP} is 0.028 pF.

Figure 3 shows the electrical lumped-element equivalent-circuit model for the NiCr resistor. In this model, R represents the RF resistance of the device under test (DUT), L is the series inductance, which is due to the finite length of the transmission-line length associated with the resistor, and C is the shunt capacitance which accounts for the RF fringing fields to the ground plane. This model assumes a symmetrical fringing capacitance due to the symmetry of the resistor structure. For the two-port circuit in Fig. 3, the Y-parameters are related to the element values by:

$$Y_{11} + Y_{21} = j\omega \mathrm{C} \qquad (3)$$

4. Variations in R/R_{dc} with frequency are shown for 20-, 135-, and 280-Ω resistors.



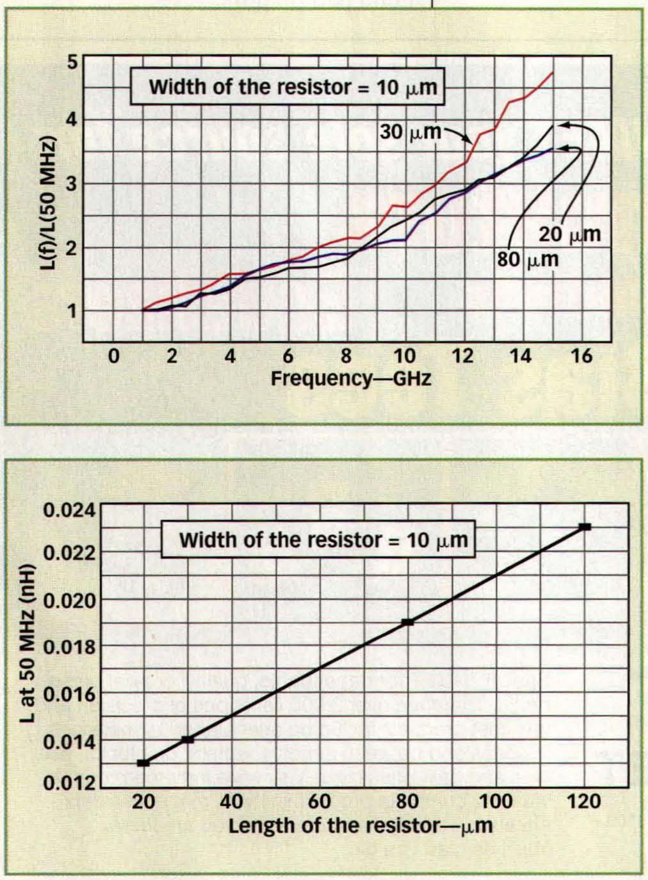
$$Y_{21} = -1/(R + j\omega \mathrm{L}) \qquad (4)$$

For $\omega^2 L^2 << R^2$, Eq. 4 may be rewritten as:

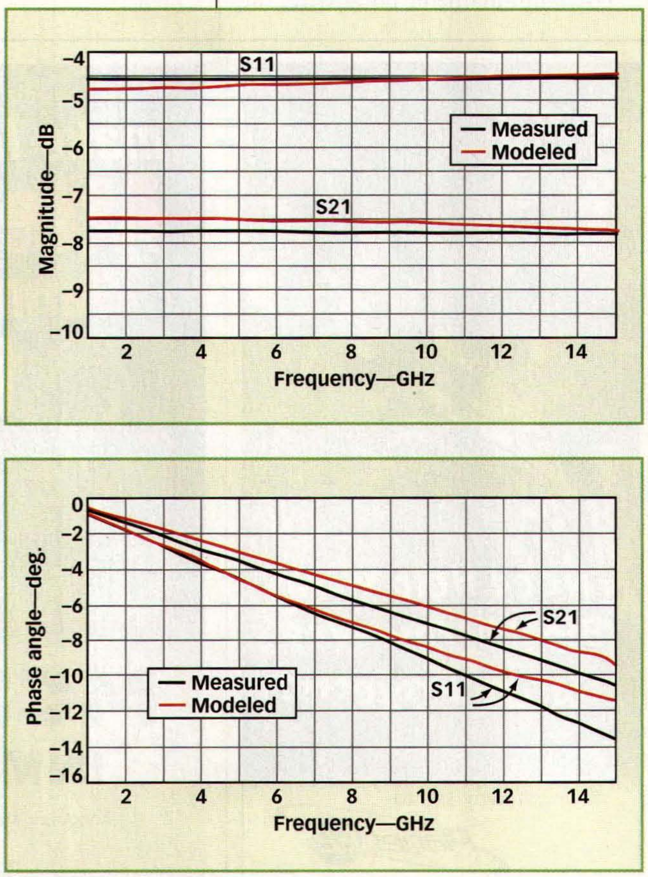
$$\mathrm{Re}[Y_{21}] = -1/R \qquad (5a)$$

$$\mathrm{Im}[Y_{21}] = \omega L / R^2 \qquad (5b)$$

The de-embedded S-parameters at the resistor planes are transformed to a Y-matrix and, using Eqs. 4, 5a, and 5b the electrical parameters R, L, and C, are computed for various frequencies. The variations of the extracted model parameters with frequency for



5. Inductor variations are shown (normalized to a value at 150 MHz) for resistors of length 20, 30, and 80 µm (a), while the low-frequency (50-MHz) inductance of the resistor is shown as a function of resistor length (b).



6. The measured and modeled values are compared for a 135-Ω resistor for (a) S_{11} and S_{21} magnitude and (b) S_{11} and S_{21} phase.

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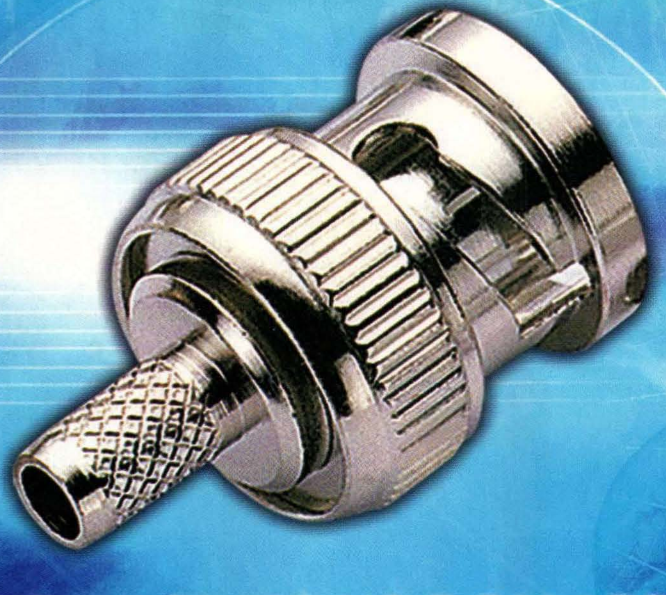

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a few resistors are shown in **Figs. 4 and 5**. Figure 4 shows the values of R normalized to R_{dc} (DC/low frequency value of the resistor) as a function of frequency for three different values of NiCr resistors. It is apparent here that R increases with frequency and this may be due to skin effects. The authors have generated a data base for resistors of various geometries and from this experimental data, have created a geometry-scalable model for parameter R as a function of frequency:

SEE EQ. 6 ABOVE RIGHT

where:

R_{dc} = the DC value of the resistor and is related to the physical parameters[6] by the relationship:

SEE EQ. A ABOVE RIGHT.

where:

δl = 1.0 µm,

δW = 1.0 µm,

R_c = the contact resistance (25 Ω-square),

R_{sq} = the sheet resistance (40 Ω-square),

l = the length of the resistor (in µm),

W = the width of the resistor (in µm), and

f = the frequency (in GHz).

The expression given by Eq. 6 is valid within ±5 percent over the frequency range to 15 GHz. Figure 5(a) shows the values of the inductance (L) of the resistor (normalized to its value at 50 MHz) as a function of frequency for three values of the resistor length. The resistor width is 10 µm for all curves. It can be seen from Fig. 5(a) that L is an increasing function of frequency. Figure 5(b) shows the dependence of L at 50 MHz as a function of resistor length for a resistor width of W = 10 µm. From Figs. 5(a) and 5(b), it can be seen that L is a strong function of resistor length and frequency. Combining the data of Figs. 5(a) and 5(b), the authors have derived a curve-fitted empirical expression for the inductance L for a resistor width (W) of 10 µm:

$$R(f)/R_{dc} = 1 + 2.0\times10^{-3} f + 3.8\times10^{-4} f^2 \qquad (6)$$

$$R_{dc} = \left[(l+\delta l)/(W-\delta W)\right] R_{sq} + 2R_c/(W-\delta W) \qquad (A)$$

$$L(f) = (a_0 + a_1 l)(b_0 + b_1 f + b_2 f^2 + b_3 f^3) \qquad (7)$$

SEE EQ. 7 ON P. 85.

where:

l = the resistor length (in μm),
f = the frequency (in GHz),
$a_0 = 0.011$,
$a_1 = 1.0 \times 10^{-4}$,
$b_0 = 0.938$,
$b_1 = 0.106$,
$b_2 = 2.7 \times 10^{-4}$,
$b_3 = 4.486 \times 10^{-4}$, and
L(f) = the resistor inductance as a function of frequency (in nH).

Similar equations have been derived for different resistor widths. The authors have found that the fringing capacitance (C) is very low and weakly dependent on frequency. For practical purposes, it may be treated as a constant value of 20 fF.

Self Consistency

To check the self-consistency of the resistor model presented here, the authors computed the S-parameters of the resistor equivalent network with the element values as obtained from the model Eqs. 6 and 7 and compared these values with measured S-parameters. **Figure 6(a)** shows the modeled and the measured (and subsequently de-embedded) values of $|S_{11}|$ and $|S_{21}|$ at the device plane as a function of frequency for a NiCr resistor of length 30 μm and width of 10 μm (the DC value of the resistor is 135 Ω). Figure 6(b) shows the corresponding values for $< S_{11}$ and $< S_{21}$—both measured and modeled. From these results, it is clear that the parameters computed from the model agree reasonably well with the measured values.

This report has offered a methodology for the RF characterization and data-based RF modeling of NiCr resistors used extensively in MMICs. The technique for extracting the parameters of the lumped-element electrical equivalent-circuit parameters has been discussed in details and based on this, some curve-fitted polynomial equations valid within ±5 percent to 15 GHz have been obtained for CAD applications. MRF

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LO Buffers/Splitters Ease LO Drive Designs

These highly integrated circuits can help fortify the design of a tunable oscillator by providing isolation from output-power variations as a function of supply and temperature.

Base-station designers are faced with the daunting task of driving down product costs while achieving superior levels of radio performance. One of the most obvious solutions is to employ greater degrees of circuit integration throughout the receive and transmit lineups. The MAX9987/90 family of local-oscillator (LO) buffers/splitters have been specifically designed with this singular goal in mind. In addition, these these components help to improve the overall performance of the LO drive lineup by offering exceptional output-power variance control, isolation, and noise performance—all critical parameters for optimizing passive mixer designs. An overview of typical LO drive circuits follows, along with a description of how the MAX9987/90 family of parts can be optimized for virtually any LO drive application.

A typical LO lineup requires a buffer amplifier to isolate and drive a passive mixer from a voltage-controlled oscillator (VCO) with relatively low output power. Most passive mixers require drive levels ranging from +14 to +20 dBm.

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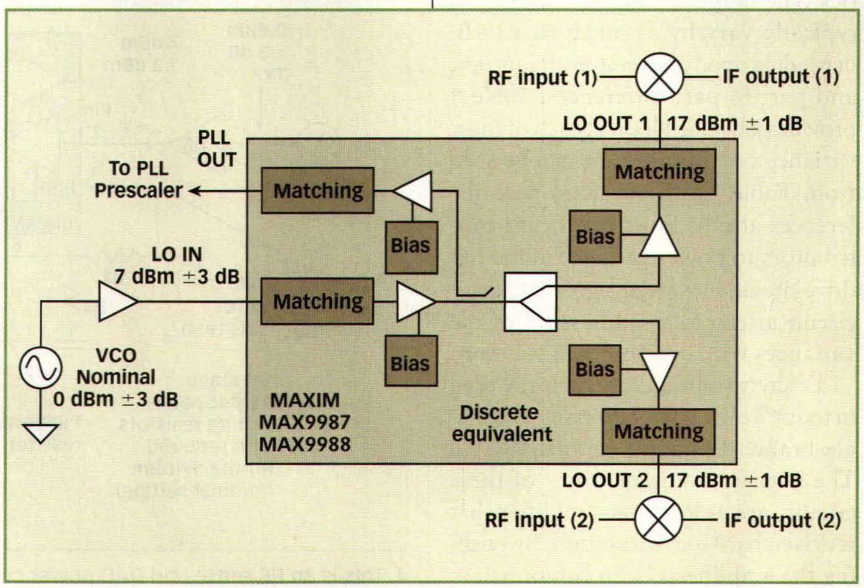
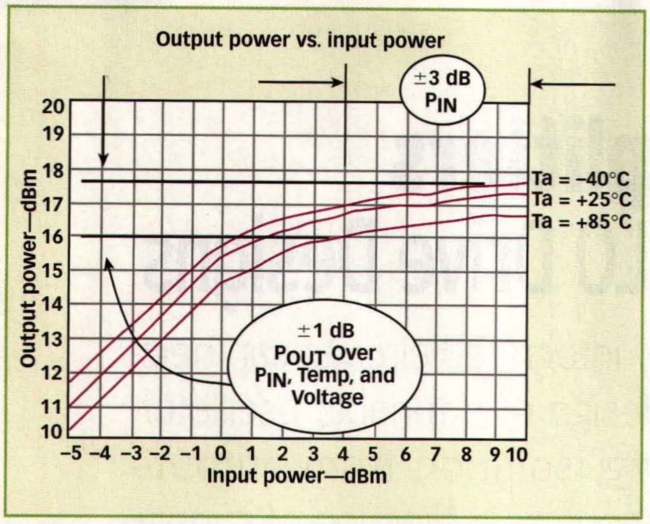
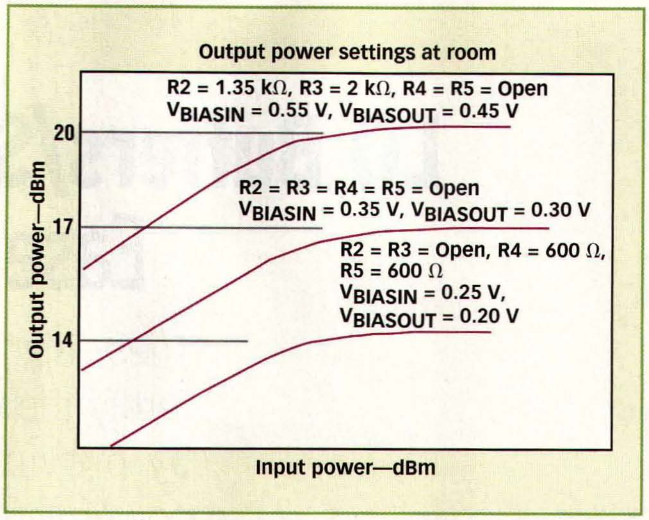


1. This is a typical application circuit using the MAX9987/9988 LO buffers/splitters.



2. These output-power characteristics for the MAX9987/90 were measured for a typical application circuit.



3. These curves demonstrate output-power level control using the MAX9987/90 biasing feature.

However, simple amplification of the VCO signal is not sufficient for optimizing mixer performance. A key requirement for any LO lineup is to maintain a nominal drive level despite temperature, voltage, and VCO drive variations. Failure to contain LO drive variance can lead to degradations in receiver (Rx) sensitivity and third-order-intercept-point (IP3) performance. For the transmit chain, LO drive variance can also impact output power, IP3, and corresponding adjacent-channel power ratio (ACPR).

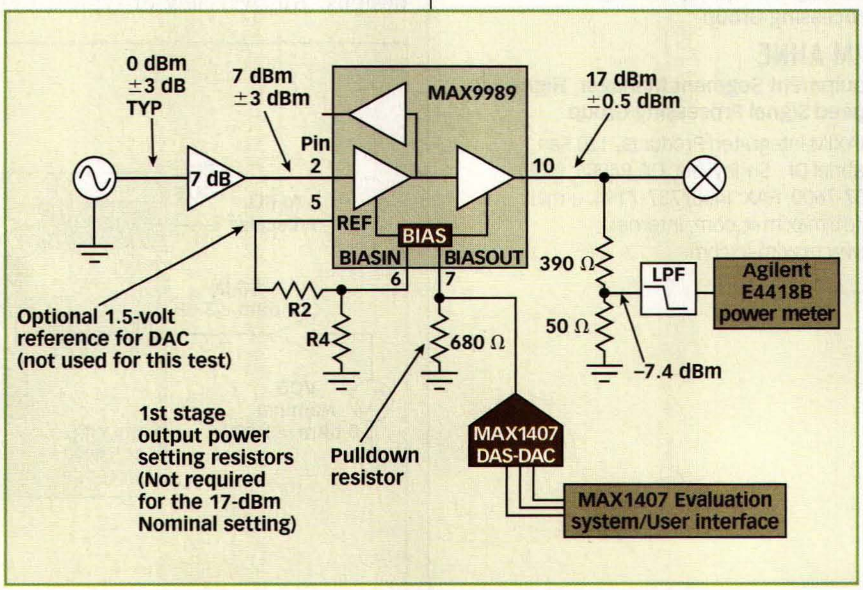
Most of the variance encountered within an LO drive circuit is directly related to the VCO's output characteristics. The output power of a VCO can typically vary by as much as ±3 dB, depending upon temperature, frequency, and part-to-part differences. **Table 1** provides a detailed look at each of these variance contributors. As can be seen from Table 1, VCO part-to-part differences are the most significant contributors to power variance in the LO drive circuit. However, a good LO drive circuit attempts to address all of the variances with one common solution.

Discrete solutions are typically used in today's high power diversity and single branch LO drive circuits **(Fig. 1.)** The overwhelming majority of these circuits use at least one amplifier that is driven hard into saturation. By pushing the amplifier(s) into compression, a relatively stable level of output drive is provided regardless of variations in input power, temperature, and supply voltage.

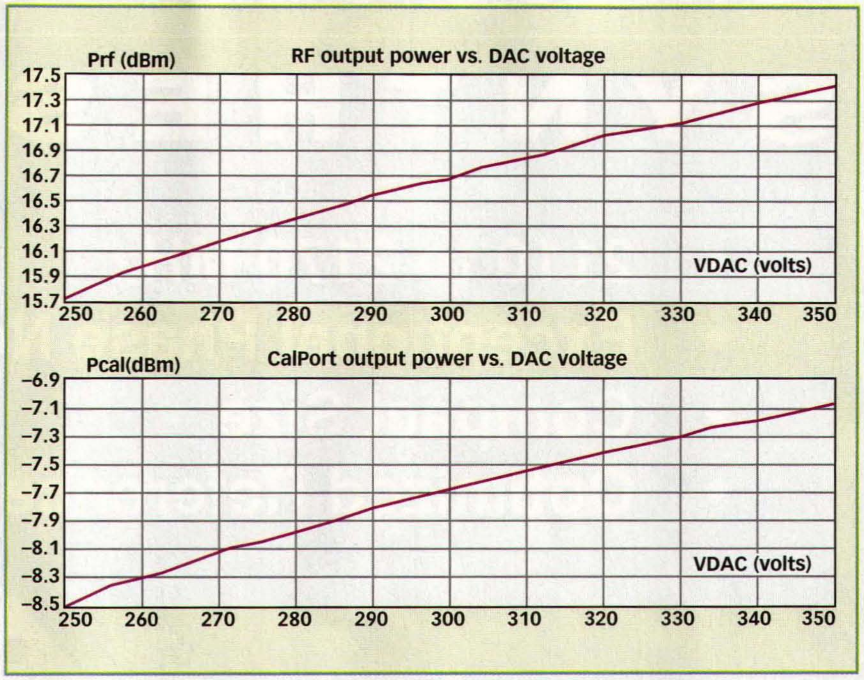
However, the drawback of these discrete solutions is that they are relatively bulky—especially when a designer uses lumped or distributed Wilkinson splitters as the representation of the power divider. Also, the parts count can be significant as noted in **Table 2.**

As shown in Fig, 1, the MAX9987/88 replaces four discrete amplifiers, a passive splitter and coupler, plus dozens of biasing components. This high degree of integration enables a designer to reduce the overall size of the LO drive circuitry by a factor of 2.5 times, while simultaneously cutting the parts count by as much as 41 percent. Table 2 provides a more detailed look at how well these integrated devices stack up against their discrete-component equivalents.

These components are ideal for cellular/Global System for Mobile Communications (GSM)/digital-cellular-system (DCS)/personal-communications-services (PCS) and Universal Mobile Telecommunications System (UMTS) base-station applications where dual, high-level LO drives are required for



4. This is an RF sense and DAC power control circuit for the MAX9989/90 (single-output) devices.



5. These measurements of RF power were made as a function of control voltage for the MAX9989.

diversity transmit and receive lineups. Single-output versions, namely the MAX9989/90, can be similarly used for single-branch systems. At the heart of each device is the on-chip buffer circuit, which provides output-to-input isolation of 40 dB to prevent LO pulling, and output-to-output isolation of 30 dB to reduce branch-to-branch interference. As an added benefit, the MAX9987/90 feature an on-board PLL amplifier which provides a convenient +3-dBm output for prescaler feedback. Each member of the MAX9987/90 family comes in a remarkably small, pin-compatible 5 × 5-mm QFN-20 package.

The MAX9987/90 series of LO buffers/splitters were specifically designed to provide LO drive control of better than ±1 dB over a wide range of temperatures (–40 to +85°C), input-power levels (±3 dB), and supply voltages (5 ± 0.25 V), all without the use of external calibration or control. **Figure 2** depicts the basic relationship between output power and input power for the MAX9987/90's typical application circuit. As shown, the device is capable of providing ±1-dB variance control over a relatively large input-power swing of ±3 dB. The designer is tasked with providing a nominal level of input power for the MAX9987/90. After this nominal level is determined, all variance control—including part-to-part variations—is handled directly by the integrated circuit (IC).

Table 1: Contributing Factors to VCO Output Power Variance

PARAMETER	PARAMETER RANGE	TYPICAL POWER VARIANCE
TEMPERATURE	–40 TO +85°C	±0.5 TO ±1 dB
FREQUENCY	±30 MHz	±0.5 TO ±1 dB
PART-TO-PART DIFFERENCES		±1 TO ±2 dB
TOTAL VARIANCE	OVER TEMPERATURE, FREQUENCY AND COMPONENT-TO-COMPONENT	±2 TO ±3 dB

Table 2: MAX9987/9988 Size, Part Count and Cost Comparison

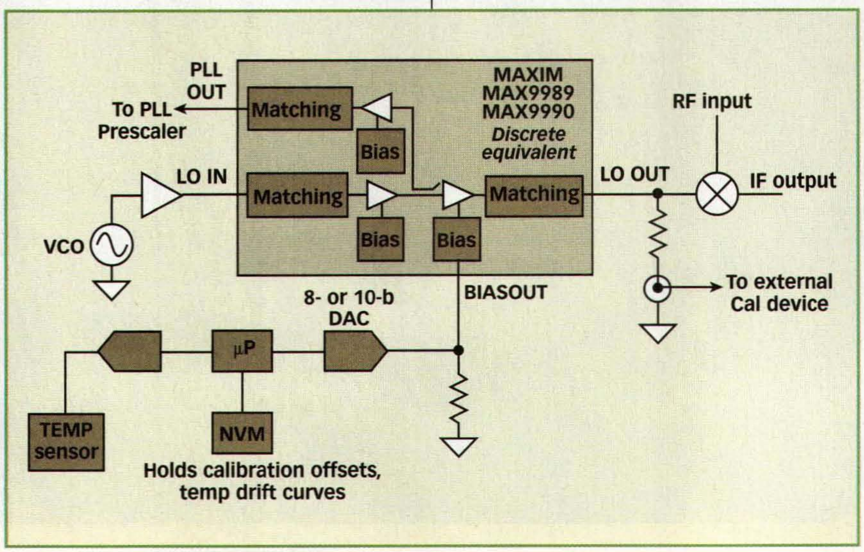
COMPONENT	MAXIM PART COUNT	COMPETING SOLUTION PART COUNT	SPACE PER PART (mm^2)	SPACE FOR MAXIM SOLUTION (mm^2)	SPACE FOR COMPETING SOLUTION (mm^2)	AVERAGE COST PER PART	MAXIM COST	COMPETING SOLUTION COST	COST SAVINGS
C	14	16	3.75	52.5	60	$0.01	$0.14	$0.16	$0.02
L	0	9	7.7	0	69.3	$0.04	$0.00	$0.36	$0.36
R	5	4	3.75	18.75	15	$0.005	$0.03	$0.02	-$0.01
AMPS	0	4	18.5	0	74	$1.10	$0.00	$4.40	$4.40
SPLITTER	0	1	31	0	31	$1.25	$0.00	$1.25	$1.25
MAX9987/88	1	0	25	25	0				
TOTAL	20	34		96.25	249.3				$6.03

The MAX9987/90 offers a nominal output level of +17 dBm (Fig. 2). Note, however, that the MAX9987/90 also possess a feature whereby the designer can precision-set the output power levels through the implementation of four external biasing resistors. In effect, these resistors determine the degree of biasing on the chip's internal amplifiers. The specified output power levels are adjustable from +14 to +20 dBm, depending upon the chosen resistor settings **(Fig. 3)**.

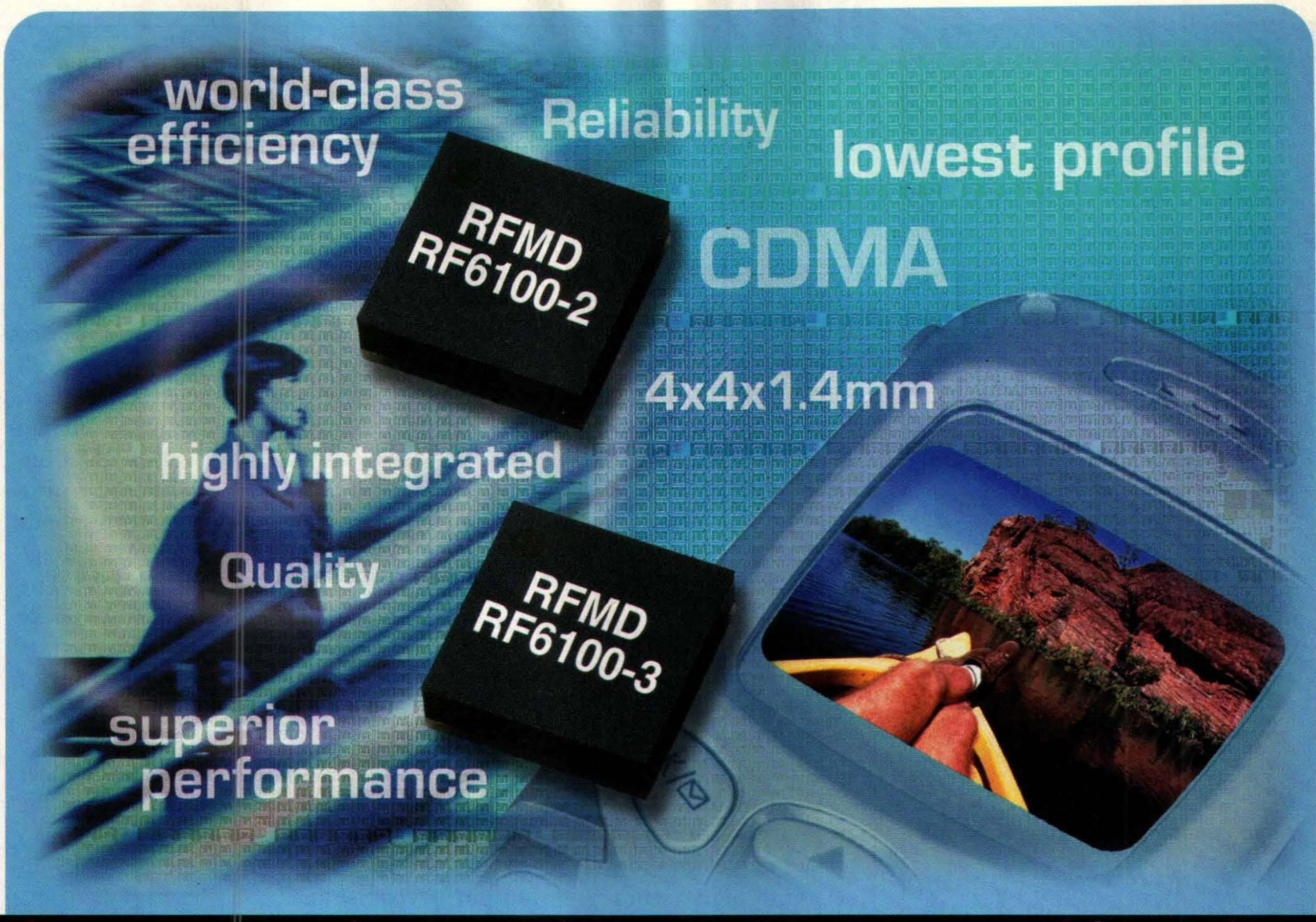
For the majority of LO drive applications, ±1 dB of variance control is more than sufficient for optimizing mixer performance. However, in certain cases, a designer may find it desirable to limit this variance to even lower limits.

The technique presented below caters to such an application by extending the capabilities of the MAX9987/90 to yield nominal output levels that are accurate to within 0.05 dB. Such adjustments allow the designer to calibrate out part-to-part differences which lead to variances in input drive level. In the case of a typical LO drive circuit, the VCO's part-to-part variations of ±2 dB can be eliminated altogether. All that remains is a very manageable delta of less than ±0.5 dB over temperature and voltage, centered around the calibrated value of output power.

The calibration process is facilitat-



6. Temperature compensation can be achieved using a digital technique.



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ed by the MAX9987/90's programmable output-power feature. Instead of using fixed resistors, it is possible to control the output power directly with a voltage applied to the reference pins. This type of control provides the option of modifying the output power at any time, and lends itself to dynamic adjustments which can be implemented during a calibration test. The proposed method, shown in **Fig. 4**, allows for testing and setting of the output power level in a production environment. Other possible implementations are suggested toward the end of this article.

For demonstrative purposes, the goal of the design shown in Fig. 4 is to set (with high accuracy) an output power level of +17 dBm on the MAX9989. Other output power levels are possible, depending upon the level of bias applied to the reference pin. In addition, this technique can be applied to any member of the MAX9987/90 family.

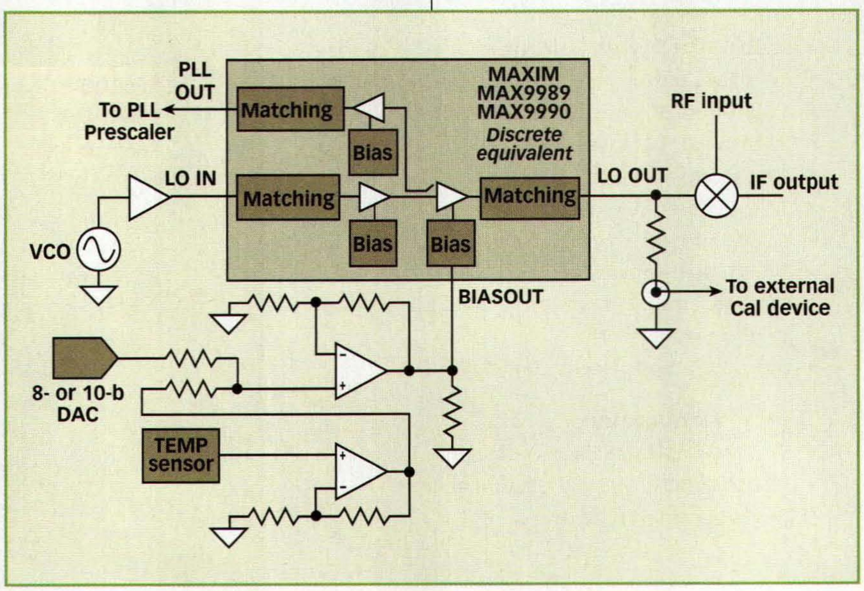
For the bench test of this circuit implementation, a constant +7-dBm RF source at 900 MHz was used to drive the MAX9989. **Figure 5** shows the measured transfer function of RF output versus digital-to-analog converter (DAC) voltage for this particular circuit. Laboratory measurements of this circuit reveal that the output power of the MAX9989 can be fine-tuned with 0.05-dB accuracy. It should be noted that, for this particular circuit, a nominal level of +17 dBm (delivered to the load) corresponds to a DAC voltage of 320 mV. The coupler used on the calibration port taps off −7.4 dBm of power from the MAX9989, and hence the designer needs to drive the bias on the device a bit higher to compensate for the 0.3-dB coupler loss.

For the majority of LO drive applications, ±1 dB of variance control is more than sufficient for optimizing mixer performance.

The following lists some key findings from the implementation presented in Fig. 4. If a 10-b DAC is used to set a voltage between 0 and 1.25 V, the control resolution will be:

Resolution = (voltage range)/$2^{\text{number of bits}}$ = (1.25 V)/2^{10} = 1.2 mV.

The control slope is approximately 0.02 dB/mV, so the resolution is effec-



7. Temperature compensation can also be provided by means of an analog technique.

tively 0.02 dB (more than sufficient for the 0.05-dB control target). It is possible to use an 8-b DAC to provide sufficient resolution, depending on the goal of the application. For measurement simplicity, the plots shown in Fig. 5 were generated using a DAC integrated within the MAX1407 (a data-acquisition system on a chip). Other standalone DACs, such as the two-channel, three-wire interface, 8-b MAX519, are suitable for this type of control as well.

The MAX1407 (in Fig. 4) has an internal reference at 1.25 V which is used for Maxim's internal testing. If another DAC is used, it is possible to use the MAX9989's internal 1.5-V reference source (available on pin 5 of the device).

A 1200-MHz coaxial lowpass filter was used to reject any second- or higher-order harmonic components that might be generated from the saturated amplifier. When measuring the load RF power directly, a lowpass filter should be used as well.

Further enhancements to the circuit in Fig. 4 are also possible; four additional possibilities include:

1. Setting the output power to levels other than +17 dBm. A designer may wish to precision set the output power to a level between +14 and +17 dBm. Doing this is simply a matter of connecting pin 6 (BIASIN) to the resistors R2 and R4 shown in Fig. 4. Suggested values of R2 and R4 are provided in Table 1.

2. It may be of interest to adjust the MAX9987/90's power level over a wide range, rather than for precision setting at a specific level. As noted above, the device's output-power level is adjustable from +14 to +20 dBm. DAC control can be used to realize these output-power levels under user control. To extend the control range, it is suggested that the bias voltages on both pins 6 and 7 are raised or lowered, rather than the bias on just pin 7. Since each pin will require different bias levels, it is recommended that the designer use two separate DACs in this implementation. Refer to Fig. 3 for details on the ideal voltages to apply to pins 6 and 7.

***Regardless** of how they are used, the MAX9987/90 are ideal parts for providing high levels of LO drive with exceptional output-power variance control.*

3. The amount of output-power variance can be reduced even further if the designer can account for changes in ambient temperature. As **Figs. 6 and 7** show, it is possible to link a temperature sensor to the bias control of the MAX9989. A positive or negative temperature slope can be implemented, allowing a user to set the power/temperature profile to extract the best qualities of the following RF stage.

4. A real-time closed-loop control system can be used for even greater accuracy. **Figure 8** represents one possible implementation based on an analog integration circuit.

Regardless of how they are used, the MAX9987/90 are ideal parts for providing high levels of LO drive with exceptional output-power variance control. By using these devices, base-station designers can dramatically improve the performance of their LO drive circuit while only using a fraction of their current component count and board footprint. MRF

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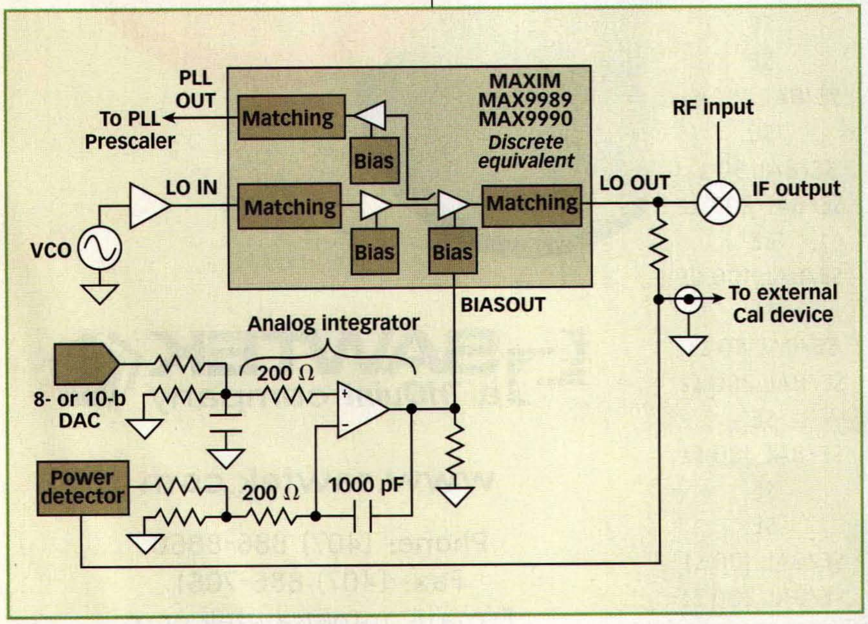

8. This analog circuitry provides closed-loop control of a VCO's output levels.

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VAT-2	HAT-2	2	2	0.20	0.10	1.20	1.2
VAT-3	HAT-3	3	3	0.15	0.12	1.15	1.1
VAT-4	HAT-4	4	4	0.15	0.08	1.15	1.1
VAT-5	HAT-5	5	5	0.10	0.06	1.15	1.1
VAT-6	HAT-6	6	6	0.10	0.02	1.15	1.1
VAT-7	HAT-7	7	7	0.10	0.05	1.15	1.1
VAT-8	HAT-8	8	8	0.10	0.04	1.20	1.1
VAT-9	HAT-9	9	9	0.10	0.02	1.15	1.1
VAT-10	HAT-10	10	10	0.20	0.03	1.20	1.1
VAT-12	HAT-12	12	12	0.10	0.05	1.20	1.1
VAT-15	HAT-15	15	15	0.30	0.05	1.40	1.1
VAT-20	HAT-20	20	20	0.75	0.18	1.20	1.1
VAT-30	HAT-30	30	30	0.30	0.38	1.15	1.1

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DESIGN

Generate Wide-Dynamic-Range WCDMA/3GPP Signals

Modern digital signal generators with internal arbitrary waveform generators can be used to create the multicarrier test signals needed to evaluate 3G base-station power amplifiers.

Testing multicarrier power amplifiers (MCPAs) for wideband-code-division-multiple-access (WCDMA)/third-generation partnership project (3GPP) wireless systems places great demands on the test-signal source. To obtain the optimum test setup for MCPAs, specific spectral and statistical characteristics of WCDMA multicarrier signals must be taken into account. Fortunately, modern vector signal generators such as the SMIQ03HD from Rohde & Schwarz (Munich, Germany) can produce signals with adequate dynamic range for testing these amplifiers.

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The complementary-cumulative-distribution function (CCDF) defines the statistics of a test signal for WCDMA/3GPP, specifying the signal's probability of exceeding a specific power threshold. To minimize costs, the dynamic range of the signal should be limited. This can be achieved in different ways. Tests of the US CDMA System IS-95 (cdmaOne) have shown that the CCDF of a CDMA carrier can be influenced by selecting specific Walsh code combinations.[1,2] The approach can also be applied analogously to 3GPP although because of its different spreading factors (in contrast to IS-95), the approach is somewhat more complex for 3GPP. Adjacent orthogonal codes in the code domain usually yield high crest factors **(Fig. 1)**. Combinations with the code channels spread evenly across the code domain are better. Figure 1 shows the CCDF of a 3GPP base-station signal with the five obligatory control channels and eight traffic channels. The crest factor can be decreased by about 3 dB through code selection.

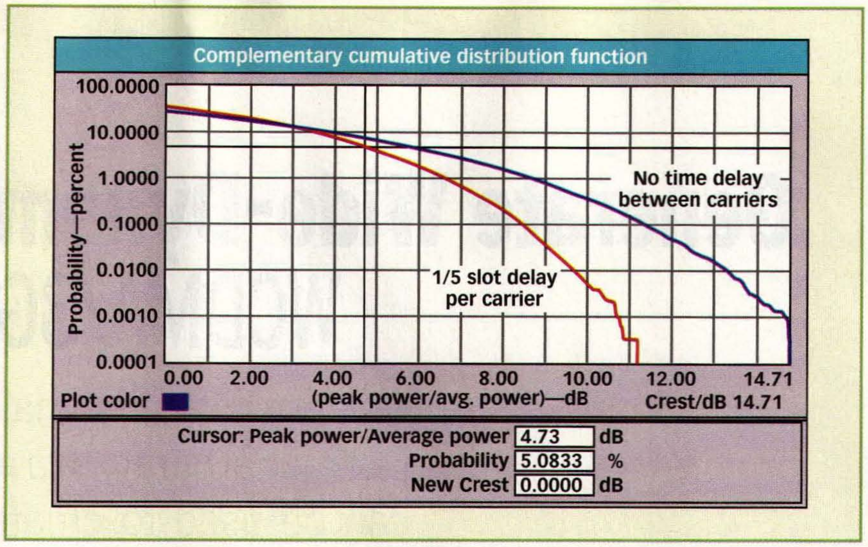
Moreover, 3GPP allows a timing offset of carrier traffic channels. Since the pilot data of the DPCH is not channel-coded, all DPCH signals have the same pilot symbols. This inevitably causes constructive interference and high power levels (if the pilot data of all channels is transmitted simultaneously). Timing offset circumvents this effect, reducing the crest factor by another 2 dB.[3]

A similar method is used with 3GPP multicarrier signals to avoid high peak envelope power values. Although the 3GPP standard defines different scrambling codes for different carriers, this is not sufficient in practice where, for this reason, the timing of the overall signals is offset on the individual carriers. The 3GPP standard advises a delay of 1/5 slot (133 μs) for signals on adjacent carriers,[4] thus helping to effectively minimize the crest factor of a multicarrier signal **(Fig. 2)**.

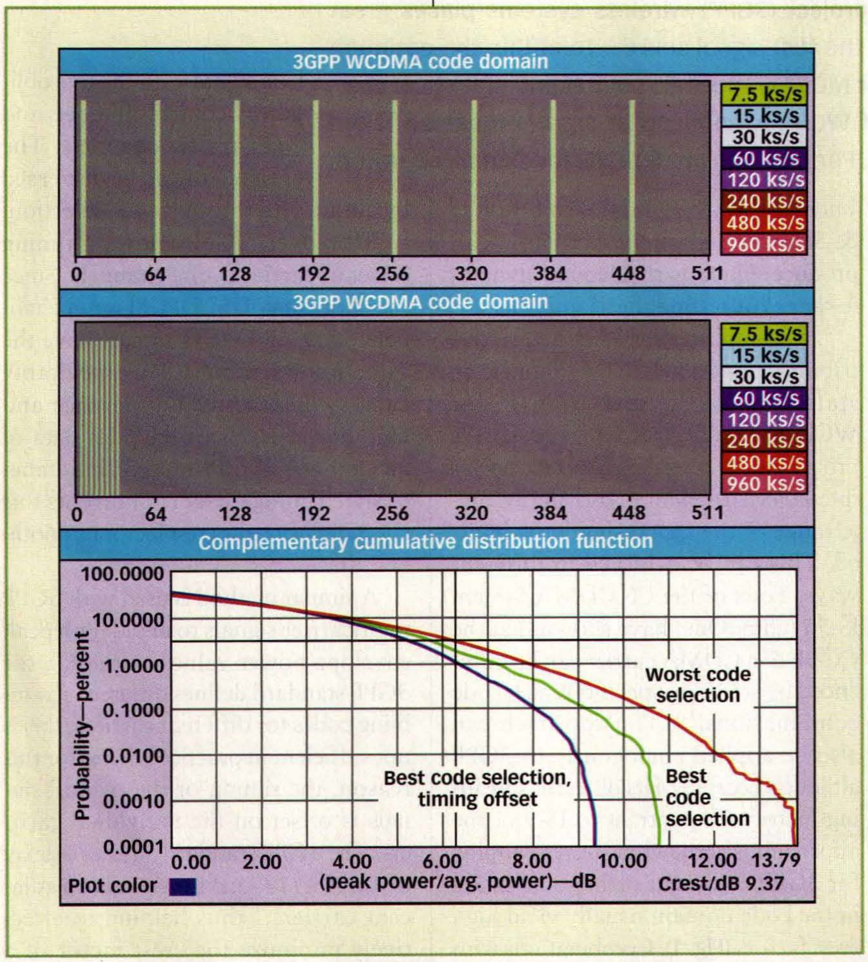
Clipping is another method of minimizing the crest factor. The sum signal

of a base station is mathematically reduced by means of a saturation function directly before pulses are shaped in the baseband. The advantage of this method is that it works for all signal configurations, independent of code combinations or timing offset. However, correct transmission of constellations with high instantaneous power is no longer ensured, and the bit-error rate (BER) increases. Clipping therefore requires improved forward-error correction. For this reason, producers of base stations combine all of these methods to maximize dynamic range.

Test signals for 3GPP PAs must emulate these possible variations. Moreover, nearly all parameters of a 3GPP test signal should be accurately determined to achieve comparable results. For this reason, 3GPP has defined test models. The 3GPP TS 25.141 specification[4] also defines unambiguous configurations for multicarrier signals **(Fig. 3)**.



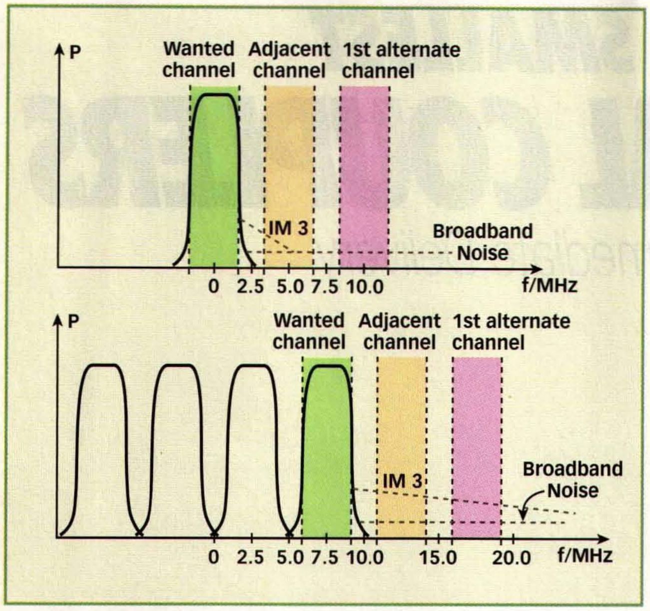
2. In this CCDF display of a four-carrier 3GPP signal, if signals of adjacent carriers are each shifted by 1/5 slot (133 µs), the red CCDF trace results. The crest factor is about 3.5 dB less than obtained without time shifting (blue trace).



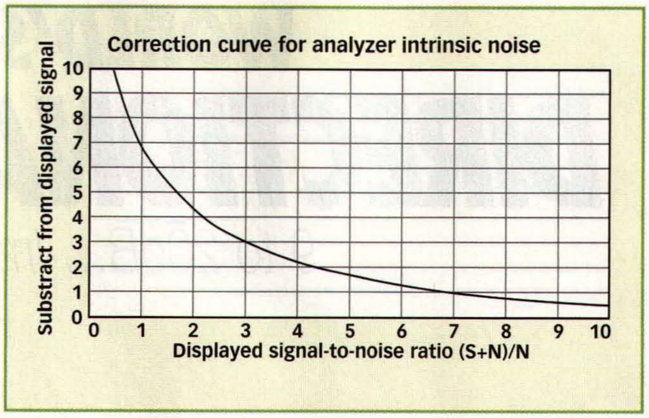
1. The display screens show code domain and CCDF plots of a 3GPP base-station signal, consisting of 8 DPCH as well as the P-CPICH, P-SCH, S-SCH, P-CCPCH control channels.

Every amplifier affects a signal in two ways: it generates additional noise, and its transmission function is linear only over a limited domain. Nonlinear components cause intermodulation. For 3GPP signals, this results in unwanted spectral components in the adjacent channels (Fig. 3). A 3GPP carrier has a width of 3.84 MHz and channel spacing of 5 MHz. The third-order intermodulation products (IM3) are in the 1.92-to-5.76-MHz range (relative to the carrier center frequency). The IM3 and wideband noise therefore contribute to the adjacent-channel leakage power. These power components may interfere with the transmission in the adjacent channel and must be minimized by achieving maximum amplifier dynamic range. Good results are usually obtained if IM3 and wideband noise make the same contributions. Wideband noise and fifth-order intermodulation (IM5) occur in the alternate channel. Since IM5 is one order less than IM3, the IM5 contribution is negligible compared to the wideband noise. The measurand is the adjacent-channel leakage ratio (ACLR), i.e. the ratio of the power in the useful channel to the power in the adjacent channel.

The situation is slightly different for multicarrier signals. A signal with four adjacent 3GPP carriers has a width of 18.84 MHz (Fig. 3). The IM3 now occurs in the 9.42-to-28.26-MHz range, both in adjacent and in alternate chan-



3. These illustrations show third-order intermodulation and wideband noise for a single 3GPP carrier (top) and a 3GPP four-carrier signal (bottom).



4. This correction signal can be used to compensate for the inherent noise of a particular spectrum analyzer.

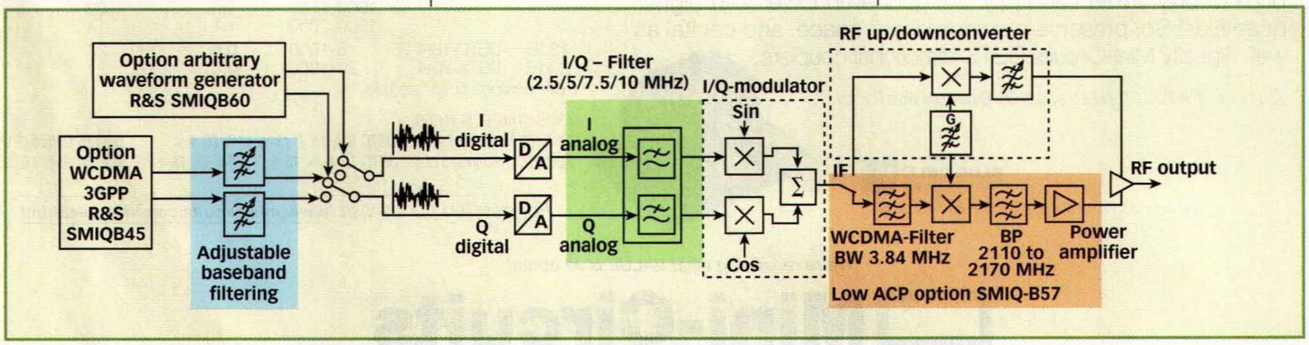
nels. In this case, the amplifier has to be driven to a lower level to achieve optimum ACLR.

Measuring instruments also generate intermodulation and noise and may contribute to the measured ACLR. **Figure 4** shows a quantitative recording for a spectrum analyzer. If the inherent noise of the analyzer is 5 dB less than the measured value (consisting of the input signal and inherent noise), it is still necessary to deduct just under 2 dB from the measured value to obtain the correct value of the input signal. To ensure that the measuring instruments do not significantly influence the overall result of the ACLR, they must exhibit ACLR values that are at least 10 dB better than those of the device under test (DUT). The measurement uncertainty of the ACLR value of the DUT is significantly higher if the contributions of the measuring instruments are of the same order as those of the DUT, or even if they are dominant (Fig. 4).

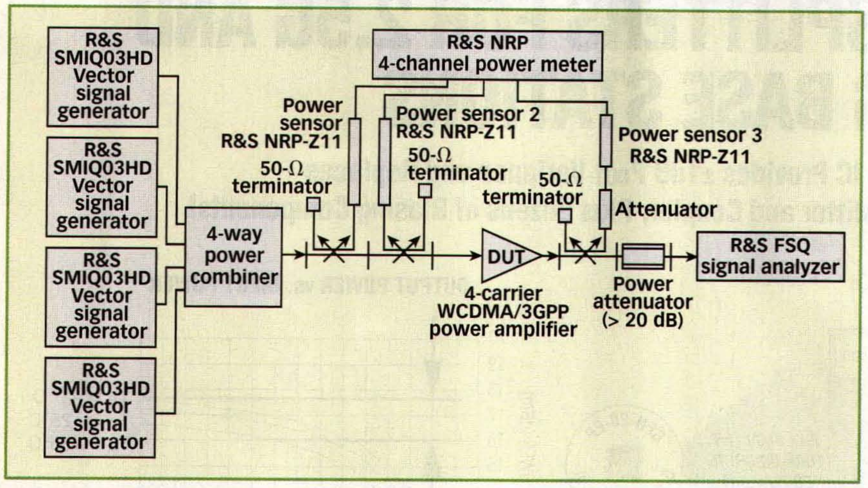
The 3GPP base-station standards specify a minimum value of 45-dB ACLR in the adjacent channel. Most producers aim for an ACLR of 50 dB for the entire base station. As a result, ACLR values of minimum 60 dB are obtained for the associated PAs. For these reasons, a signal generator should exhibit an ACLR of 70 dB or better in the adjacent channel, which is a great challenge when designing signal generators **(Fig. 5).**

As noted, the maximum dynamic range of an amplifier also depends on the signal to be amplified. For ACLR improvements, this principle can also be applied to signal generators. The SMIQ03HD vector signal generator actually features two output modes: low distortion and low noise. In the first, some internal dynamic range is sacrificed to minimize intermodulation products. This mode is optimally suited for measurements in the adjacent channel and is preferable if a 3GPP multicarrier signal is generated by a single generator. In the second mode, the generator features a high internal dynamic range to maintain low wideband noise levels. This mode is for measurements in alternate channels with 3GPP single-carrier signals.

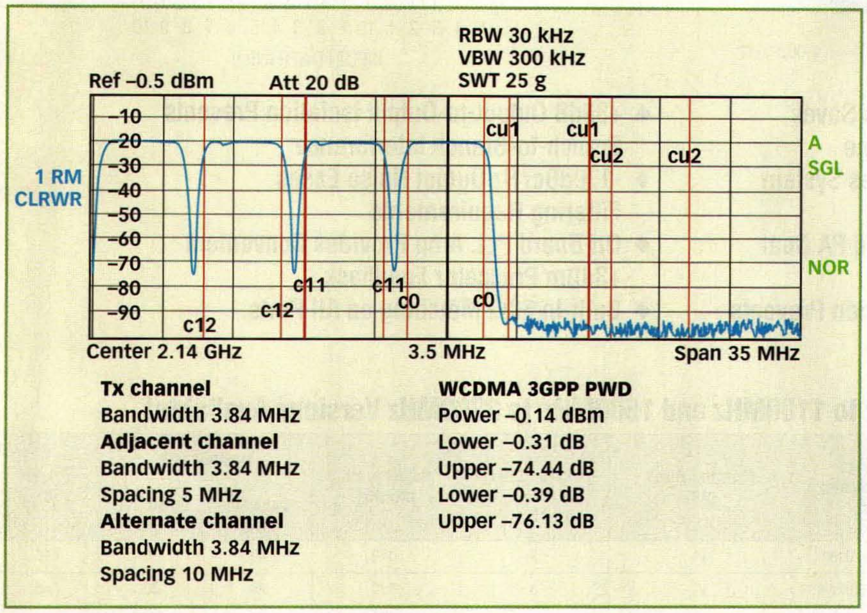
I/Q filters suppress the wideband noise of the baseband modules, thus improving the ACLR. Although these I/Q filters do influence the I/Q signals, it is possible to avoid higher vector errors by means of appropriate precorrection of the baseband signal. The SMIQ03HD provides this for every signal, whether it is generated internally or calculated externally and replayed by



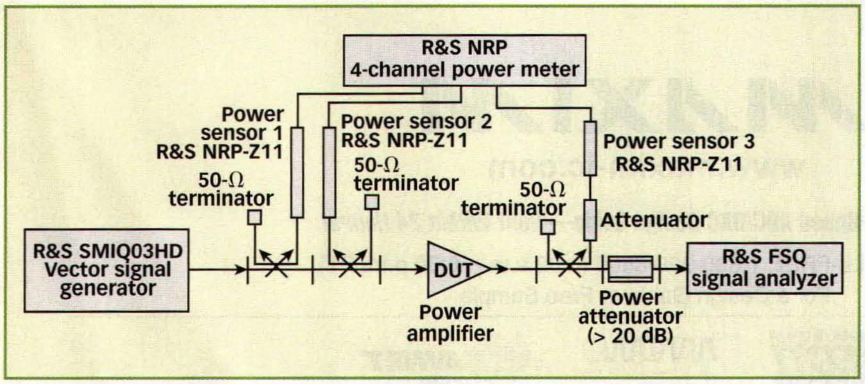
5. This block diagram shows how complex signals are created with the aid of an optional arbitrary waveform generator in the SMIQ03HD digital signal generator.



6. This is a typical test setup for testing MCPA. The maximum dynamic range is obtained by using four vector signal generators.



7. This four-carrier 3GPP signal, with 74-dB ACLR in the adjacent channel and typically 76-dB ACLR in the alternate channel, was generated with the four-generator setup of Fig. 6.



8. This cost-effective multicarrier amplifier test setup requires a single SMIQ03HD vector signal generator with built-in arbitrary waveform generator.

means of the internal arbitrary waveform generator. I/Q filters for 3GPP signals with one to four carriers are available for four different I/Q bandwidths (2.5/5/7.5/10 MHz). The I/Q filters can also be used for all RF output frequencies and levels.

To achieve maximum dynamic range in the ACLR, band-optimized solutions should be considered. The SMIQB57 option for the SMIQ03HD is based on a surface-acoustic-wave (SAW) filter operating at 380 MHz. The filter processes a generated single carrier without influencing the carrier edges and attenuates adjacent-channel interference with typically 31-dB suppression. A subsequent PA stage increases the RF signal to an output power of +30 dBm peak envelope power (PEP).

By using the SMIQB57 option, the SMIQ03HD achieves ACLR values of typically 77 dB in the adjacent channel and typically 82 dB in the alternate channel for a 3GPP single-carrier signal (3GPP test model 1, 64DPCH). These values satisfy the most-stringent demands and were previously never achieved without resorting to external bandpass filters (which are limited to a single frequency and increase insertion loss) or interference methods.

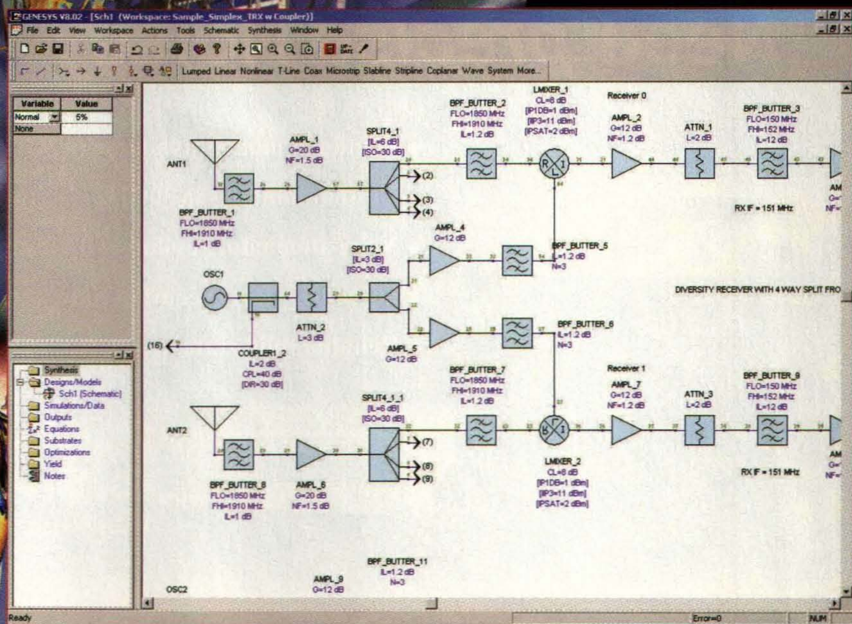
Another strategy for expanding the dynamic range is based on the interference method. In this approach, reference and test-signal paths are created by means of a power splitter. Unfortunately, this approach is not suitable for production due to the difficulty of matching the delay of the reference-signal path to that of the measurement-signal path.

Fortunately, the SMIQB57 option simplifies this approach, allowing the generation of reproducible RF level settings in particular for amplifiers using feedforward correction. By using an internal arbitrary waveform generator and personal-computer (PC) software, it is possible to generate 3GPP single-carrier and multicarrier signals as well as combinations of 3GPP carriers and signals of other standards.

Figure 6 shows a typical setup for testing WCDMA MCPAs. To generate a

Systems From Start to Finish

Simulation in the Spectral Domain



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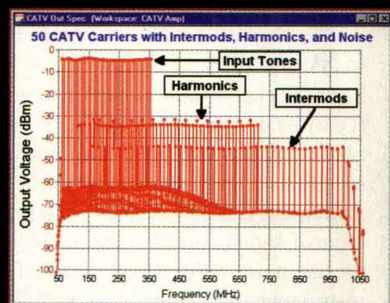

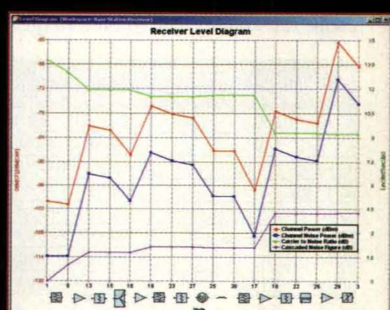

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WCDMA/3GPP four-carrier signal with optimum ACLR, four R&S SMIQ03HD generators, fitted with the high ACLR R&S SMIQB57 option, are linked by means of a four-port power combiner. Timing delays between the individual carriers are implemented via suitable generator triggering. Power sensor 1 measures the power of the sum signal after the combiner, while power sensor 2 measures the reflected power. The output power can be exactly determined by means of power sensor 3. For spectral and ACLR measurements, a spectrum analyzer (such as a model FSQ) featuring wide dynamic range and high linearity is connected to the second port of the output coupler.

Since measurement of ACLR is a relative power measurement, the high linearity of the spectrum analyzer can be exploited. However, the use of a power meter, such as the R&S NRP with a model NRP-Z11 power sensor, is indispensable for a sufficiently accurate measurement of the absolute power of the amplified signal. It allows simultaneous operation of as many as four power meters with a dynamic range of 90 dB. In addition, it also measures wideband modulated signals with a precision associated with thermal power meters.

The dynamic range achieved by means of this test setup can be easily determined by measuring the ACLR without the DUT. By using four Vector Signal Generators R&S SMIQ03HD with a 3GPP four-carrier signal, an ACLR of typically 74 dB in the adjacent channel and typically 76 dB in the alternate channel **(Fig. 7)** can be achieved.

A one-generator approach offers the most cost-effective solution for testing MCPAs **(Fig. 8)**. In this method, a four-carrier signal is generated by means of the SMIQ03HD's arbitrary waveform generator. The arbitrary-waveform-generator signal includes the required timing delay between carriers. The one-generator approach does not provide the same ACLR dynamic range as a four-generator approach since the bit resolution of the digital-to-analog converter (DAC) in the arbitrary waveform generator and the wideband noise of the I/Q modulator limit the available dynamic range. For each 3GPP four-carrier signal (always test model 1, 64DPCH), typically 62 dB in the adjacent channel and typically 64 dB in the alternate channel can still be obtained. MRF

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Using HBT PCS CDMA handset power-amplifier modules

EFFICIENT OPERATION is needed from power-amplifier (PA) modules employed in Korean personal-communications-services (PCS) code-division-multiple-access (CDMA) handsets. Fortunately, an application note from ANADIGICS, Inc. (Warren, NJ), "KPCS CDMA 4mm × 4mm Power Amplifier Modules," explains how to use compact heterojunction-bipolar-transistor (HBT) PA modules in these products for high efficiency when operating from a single lithium-ion (Li-ion) battery.

The application note explains how the input and output of the amplifier modules are impedance matched for optimum performance in 50-Ω systems. A minimum number of additional external components are needed for proper RF bypassing. The note includes construction details on an evaluation board constructed of 0.014-in. (0.036-cm)-thick GETEK material with 0.0257-in. (0.065-cm)-wide copper (Cu) traces. The printed-circuit-board (PCB) material has a dielectric constant of 4.37 at 1 GHz. The bypass capacitors include several 0.01-μF components and several 22-μF tantalum capacitors.

The application note details the type of test equipment needed to evaluate the PA modules, including a trio of DC power supplies, an RF spectrum analyzer, a CDMA function generator, an RF surface-acoustic-wave (SAW) filter, an isolator, and RF power meter, and several low-loss couplers. The note recommends that an engineer first evaluate the characterization sheet supplied with each PA module before testing the device or connecting the bias pins. A turn-on sequence is provided for guidance in safely operating each PA module.

The note also offers advice on completing a layout with the PA modules. A sufficient number of plated through holes should be placed under the module in order to channel heat away from the device. Also, contact should be made between the metal slug on the PA module and the PCB. For more information, download a copy of the application note from the company's website.

ANADIGICS, Inc., 141 Mount Bethel Rd., Warren, NJ 07059; (908) 668-5000, FAX: (908) 668-5132, e-mail: Mktg@anadigics.com, Internet: www.anadigics.com.

The ultrawideband (UWB) receiver and transmitter simulation is based on the use of the company's SystemView system simulator.

Simulating PPM UWB transmitters and receivers

ULTRAWIDEBAND (UWB) technology relies on transmitting short pulsed waveforms consisting of one or more cycles of an RF waveform. Once strictly a military technology, UWB approaches are beginning to find applications in commercial electronic systems. In keeping pace with increased design interest in UWB technology, Elanix (Westlake Village, CA) has released application note AN139A, "Ultra Wide Band (UWB) Transmitter and Receiver Simulation Using Pulse Position Modulation (PPM)."

The UWB receiver (Rx) and transmitter (Rx) simulation is based on the use of the company's SystemView system simulator. The modeled system employs a 40-MHz clock using pulse position modulation (PPM) to transmit information. At the front end of the transmitter's modulator, the data to be transmitted are represented by an eight-level bipolar pseudorandom-noise (PN) sequence. These data are combined with a low-amplitude dithering signal. The clock drives an analog integrate-and-dump circuit to create a ramp signal.

In the model, the Tx's output goes through a path loss of 50 dB and antenna noise is added to the signal before it enters the receiver model. The Rx's input filter is a three-pole Butterworth bandpass design with 3-dB points at 1.6 and 7.0 GHz. An RF amplifier with 14-dB gain follows the filter. For a first-pass simulation, a tunnel diode is used for peak-detection modeling. The tunnel diode has a region of negative resistance, where the current decreases as the voltage is increased. The negative resistance, which helps deliver fast switching time, is modeled by using an operational amplifier (opamp) hysteresis function block (or token, as they are called in SystemView). The tunnel diode's output is amplified, passed through a highpass filter, and sent to a set/reset latch. For more information, download a copy of the note from the company's website.

Elanix, Inc., 5655 Lindero Canyon Rd., Suite 721, Westlake Village, CA 91362; (818) 597-1414, FAX: (818) 597-1427, Internet: www.elanix.com.

cover story

Chip Set Adds Embedded GPS

Two companies team to provide a "universal solution" for embedded Global Positioning System (GPS) capabilities in portable wireless products.

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Global-positioning technology is finding its way into more and more wireless products, sometimes by Federal mandate. The E911 ruling by the United States Federal Communications Commission (FCC), which requires position-location capability in new cellular telephones, has brought GPS technology to millions of consumers. As those users become more familiar with the capabilities of GPS, the demand for positioned-based data is certain to accelerate. 2.5G and 3G wireless networks promise to provide the increased data capacity these new location-based services will demand. In response to increased demands for embedded GPS functionality, two California companies have joined forces to create a low-cost, low-power Global Positioning System (GPS) chip set to address the challenge.

The chip set teams the UPB1008K GPS receiver integrated circuit (IC) from California Eastern Laboratories (Santa Clara, CA) with the Opus One system-on-a-chip (SoC) baseband IC from eRide (San Jose, CA). The two-chip set forms a "universal hardware" solution in that it operates independently of wireless interface standards and independently of the host product's central processing unit (CPU) and operating system. The advanced GPS chip set delivers fast acquisition times, high sensitivity even when used indoors, and software designed to make the integration into wireless products easier than ever before. The design promises faster time-to-market, lower manufacturing costs, and ultimately, lower cost to consumers.

The UPB1008K **(Fig. 1)** combines a low-noise amplifier (LNA), a double-conversion downconverter, and a phase-lock-loop (PLL) frequency synthesizer. It also includes 2-b analog-to-digital converters (ADCs) to generate 2-b digitized outputs and can operate on supply voltages as low as +2.7 VDC (the nominal supply voltage is +3 VDC). In the downconversion process, the first intermediate frequency (IF) is at 175.164 MHz while the second IF is at 132 kHz.

An on-chip IF automatic-gain-control (AGC) amplifier provides an adjustable gain range of more than 30 dB. Fabricated with a 25-GHz cutoff-frequency silicon bipolar process, the IC is supplied in a 36-pin QFN package.

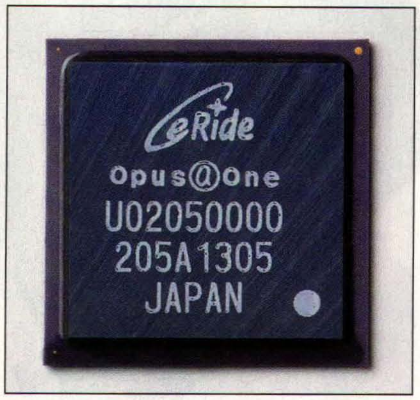
The baseband IC **(Fig. 2)** features operation at +1.8-VDC core and +3.3-VDC I/O, with peak power of only 300 mW for the first indoor fix (performing high sensitivity searching of all satellite with up to 44,000 code and frequency hypotheses), and then reduced power of 100 to 200 mW power for subsequent fixes (continuing to track all satellites with fewer hypotheses for weak signals or conventionally for stronger signals to acquire the 50-b/s GPS data message), and 30 mW in standby mode. The IC supports –155 dBm indoor sensitivity, and requires only 3 to 5 s to gain a satellite fix outdoors and only 10 to 20 s indoors to capture the needed satellite signals for a GPS location fix. The IC is supplied in a 9 × 9-mm ball-grid-array (BGA) package.

The Opus One baseband IC combines state machines, peripheral devices, and a low-frequency clock for high-performance operation without need for external memory.

The IC features two state machines. The first, the Opus State Machine (OSM), handles all codes and internal frequency generation and correlation and provides the interface between baseband hardware and software. The second, the Firmware State Machine (FSM), incorporates an indoor state machine (IDSM), an outdoor state machine (ODSM), and a time-tracking state machine. The ISM supports indoor sensitivity to –155 dBm in 1-s dwells. The ODSM is designed to search all 32 GPS satellites with –142-dBm sensitivity using a search window of two 10-ms dwells. The TSM collects the navigational data and provides synchronous measurements so that GPS time and navigation data can be decoded and assimilated (allowing the Opus One to be used all as a reference station for the eRide reference network).

The baseband IC has an effective 44,000 correlates in each 10-ms search window, with correlation performed in the time domain rather than the frequency domain. By doing these correlations and configurations in the time domain rather than frequency domain, Opus allows more efficient use of hardware and memory across the different tracking modes. As a result, the baseband processor can perform correlation of as many as 120 satellites in parallel. This search power can be configured to perform the equivalent correlation of up to 130 frequency hypotheses in parallel. The use of two different state machines in the Opus One IC addresses the challenge of cross correlation, which is the mixing of fading or low-level signals with higher-level signals as well as the mixing of multipath signals.

1. The UPB1008K GPS IC packs an LNA, frequency downconverter, and PLL frequency synthesizer into a 36-pin QFN enclosure.



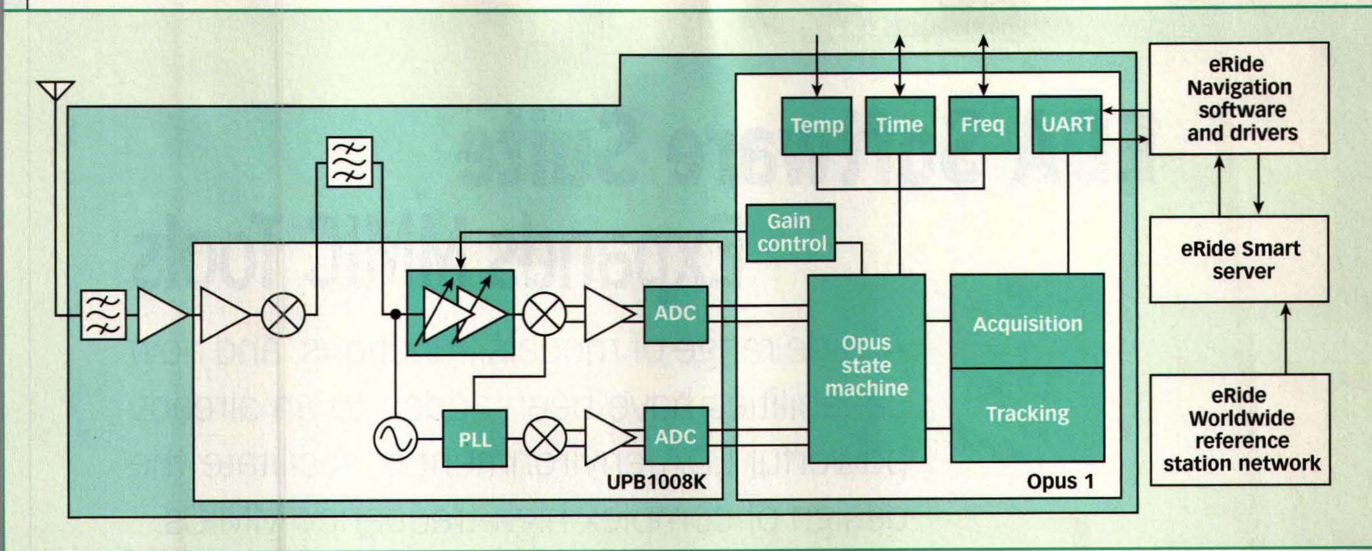
2. The Opus One baseband IC combines state machines, peripheral devices, and a low-frequency clock in a 10 × 10-mm ball-grid-array (BGA) package.

Other Opus One firmware logic handles all of the peripheral support operations. It provides a real time clock, synchronizes time and frequency across platforms, compensates for temperature, and using patented software, and compensates for crystal-oscillator drift without the need for input from outside the receiver (allowing for the use of lower-cost crystal oscillators with the chip set).

The time required to integrate a weak GPS signal is often too long to be commercially practical. To speed processing, the Opus chip automatically optimizes its search and tracking power based on the starting information available. On a cold start (no starting information), Opus One searches for all 32 GPS satellites, each of which has its own unique pseudo-random noise (PRN) code. The baseband processor begins with quick wide-bandwidth searches, then automatically transitions to time-track to collect navigation data. If more starting information is available, its search power is automatically configured to look for satellites in a narrower bandwidth, effectively increasing its power to deliver higher sensitivity. This results in practical times for the first fix: 3 to 5 s outdoors and 10 to 20 s indoors. Opus One also has the ability to track the carrier phase and demodulate the 50-b/s GPS Navigation message. This allows Opus One to fix autonomously from aiding data.

To further speed navigational computations, the eRide software uses its own portable math libraries. Its floating-point library has the ability to do sub-meter positioning without an external floating point or transcendental functions. It also has the ability to do fixed-point calculations, which speeds up matrix operations, allowing parallel fix solutions for integrity monitoring.

The unique software is designed to require very little computational power on the part of the host CPU, and very little random-access memory (RAM). Besides being efficient, it facilitates the integration of GPS capability into mobile platforms with limited available processing capability. It requires just one task slot and one serial interrupt from



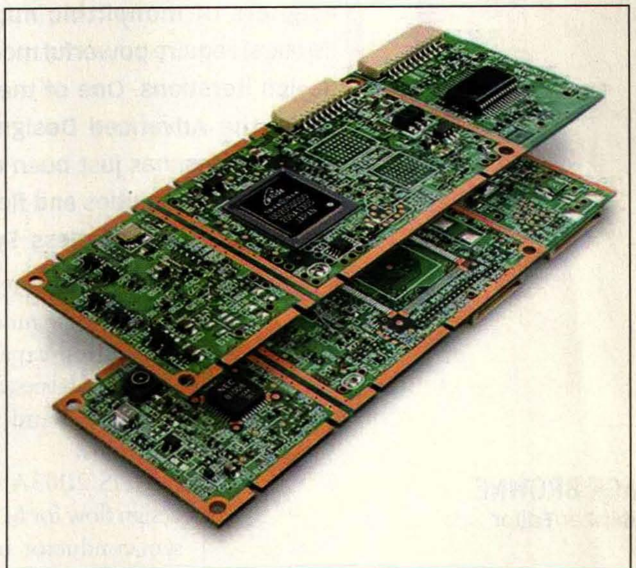
3. A complete embedded GPS solution consists of the UPB1008K and Opus One ICs, a few external components, and software and network support.

the host platform schedule in order to operate.

The software's Omni mode is a near-autonomous GPS solution with operation in either assisted or autonomous modes. In assisted mode, satellite positioning and timing data, along with an approximate position of the receiver, are all provided by the network via eRide's Smart Server and Worldwide Reference Network. In autonomous mode, aiding data are not needed. This network gathers, processes, and stores navigational data and satellite orbital models, and then communicates the data to a customer via TCP/IP, SMS, or control channels. The Omni software is designed to operate autonomously, but then tap into aiding data when needed. The instantaneous availability of this stored reference data—with no real-time interruption—helps reduce the time to first fix and ensure high accuracy.

From simple positioning systems to major enterprise-level data delivery networks, this flexible architecture **(Fig. 3)** makes it possible to scale the software to match the bandwidth of the host application. Integration is simple and straightforward: The chip set connects to the host processor via a two-way RS-232 interface. Navigation software and drivers are written in C language making them easy to port to the host CPU software. The Smart Server and Worldwide Reference Network use the open Java Messaging Service (JMS) enabling deployment into virtually any wireless infrastructure, independent of its air-interface standard.

4. Complete evaluation boards are available to test the performance of the two GPS ICs.



Typically, the GPS chip set requires just 6 million instructions per second (MIPS) processing power available from the host CPU, with 32 kB of available RAM, and 100 kb of instruction memory to perform position, velocity and timing calculations using eRide's proprietary protocols. This low overhead frees up memory and processing power for other applications within the host processor.

The two IC suppliers have developed a number of tools to assist designers in adopting their chips. These include application circuit reviews, a developer's kit and reference design **(Fig. 4)**, Internet-based technical support, a bill of materials (BOM) and target pricing for a complete system, and flexible licensing strategies for the use of the hardware intellectual property (IP).

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eRide, Inc., 3450 California St., San Francisco, CA 94118; (415) 359-9500, FAX: (415) 345-1443, Internet: www.eRide.info.

EDA Software Suite Expands MMIC Tools

A wide range of models, functions, and new capabilities have been added to an already powerful EDA environment to facilitate the design of complex high-frequency MMICs.

JACK BROWNE
Publisher/Editor

Designers of monolithic microwave integrated circuits (MMICs) require powerful modeling tools to avoid excessive design iterations. One of the most powerful MMIC design tools, the Advanced Design System (ADS) from Agilent Technologies, has just been upgraded as ADS 2003A, with expanded capabilities and flexibility. Demonstrated for the first time at the Wireless Systems Design Conference & Expo (San Jose, CA), ADS 2003A incorporates new models and design kits, verification capabilities, file manipulation capabilities, and improved schematic creation and layout-modification functions.

ADS 2003A offers an improved design flow for MMIC developers. New semiconductor models, for example, include the third generation of the TriQuint-only transistor model (TOM3), a TriQuint-modified Materka transistor model, and an Angelov Chalmers device model. The software suite features foundry support for a wide range of facilities, including TriQuint (Hillsboro, OR), TRW (Redondo Beach, CA), and Vitesse Semiconductor (Camarillo, CA).

The Advanced Model Composer in ADS 2003A allows designers to create arbitrary user-defined parameterized shapes (including matching networks), a wide range of passive components including spiral inductors, metal-insulator-metal (MIM) capacitors, and thin-film resistors, or draw from a large library of microstrip and stripline structures and components. Parameterized models are created with the Momentum planar electromagnetic (EM) simulator as the modeling source.

ADS 2003A features new schematic circuit-design capabilities, with new DesignGuides for wireless-local-area-networks (WLANs) and time-duplex, spatial-code-division-multiple-access (TD-SCDMA) systems. It also includes applications for use with load-pull impedance-tuner systems from Focus Microwaves (Dollard-des-Oreamux, Quebec, Canada) and Maury Microwaves (Ontario, CA), Smith-Chart-based impedance-matching tools, and a new transistor-biasing tool.

A new layout feature, called "Edit-in-place," allows designers to edit the subnetwork of a larger design while working from a top-level layout diagram. The effects of changes on the subnetwork can be seen while viewing the surrounding design artwork. **Agilent Technologies, 1400 Fountaingrove Pkwy., Santa Rosa, CA 95403; (707) 577-4631, FAX: (707) 577-5260, Internet: www.agilent.com/find/eesof.**

300-MHz Dual-Mac DSPs Break The Cost Barrier

This pair of digital signal processors flaunts the industry's lowest power consumption while nurturing product differentiation and functionality.

NANCY KONISH
Technology Editor

Digital signal processors (DSPs) enable advanced signal-processing functions in communications system, including implementation of complex filters. To meet an increasing need for complex DSP functions at reasonable prices, Texas Instruments, Inc. (Dallas, TX) has announced a pair of 300-MHz, dual-MAC processors with starting prices of $5.00: models TMS320VC5501 and TMS320VC5502. The processor pair, which are designed for low power consumption of only 200 mW, extend the company's TMS320C5000 platform to 32 code-compatible devices.

This DSP pair flaunts a highly integrated peripheral set that includes 32 KW DARAM and 16k ROM, a 32-b external memory interface (EMIF), and 16 kB of instruction cache. The I-Cache architecture allows the DSPs to have more memory at a lower cost **(see figure)**. It also enables increased flexibility, more external memory options, and reduced latencies. Also notable in the peripheral set are a 16-b/8-b enhanced host port interface (HPI); six-channel direct memory access (DMA) supporting internal and external transfers; an I^2C interface to microcontrollers and codecs for interchip communication; and up to 76 general-purpose I/O pins.

The C5501 and C5502 are actually the first 300-MHz DSPs to support temperatures ranging from –40° to +85°C. They can therefore cater to industrial applications that require extended temperature. For applications that demand lower cost, the C5501 DSP offers low power and high performance with reduced RAM and EMIF capability.

The company also credits its C55x C compiler technology with providing the devices' higher performance and increased memory. The smaller code size contributes to the low cost. The C55x also has 40 percent fewer cycles than some competing DSP compiler technologies.

The TMS320VC5501 and TMS320VC5502 DSPs are the first of their kind to be offered in low-profile quad-flatpack packaging (LQPF). Samples of the C5502, which can be supplied in a 24 × 24-mm, 176-pin LQFP or a 176-pin MicroStar BGA housing, are available for $9.95 each in quantities of 10,000. The C5501 DSP will be sampling in the third quarter of 2003 for $5.00 each in 10,000-unit quantities. The company also offers a 200-MHz version of the C5502 DSP for $7.95. **Texas Instruments, Inc., 12500 TI Blvd., Dallas, TX 75243-4136; (800) 336-5236, Internet: www.ti.com.**

With the I-Cache architecture, the program and data no longer need to be on chip. As a result, these DSPs are more powerful and cost effective.

Directional Couplers Are Suited For Small PAs

A NEW FAMILY OF "pico"-sized directional couplers have been introduced in Xinger®-brand package style. The 10- and 20-dB units are well-suited to today's increasingly small power

amplifiers (PAs)—measuring 0.2 × 0.25 × 0.065 in. (0.58 × 0.635 × 0.1651 cm). Key specifications include: frequency of 1.7 to 2.0, 2.0 to 2.3, and 2.3 to 2.7 GHz; power handling of up to 20 W; insertion loss of 0.20 dB/typ; and return loss of 23 dB/typ.

Anaren Microwave, Inc., 6635 Kirkville Rd., East Syracuse, NY 13057; (315) 432-8909, FAX: (315) 432-9121, Internet: www.anaren.com.

T Switch Offers Solution For Redundancy Systems

THE HIGH-POWER T SWITCH is a space-qualified unit (511H-730322) that offers a solution for S-band and C-band redundancy systems. Maximum weight of the High-Power T

Switch is 195 g. DC characteristics include +32 to +43 VDC (+42 VDC nominal) operating voltage and 510 mA (max) operating current at +43 VDC and 20°C. Equipped with a random latching actuator, this device switches in less than 25 ms.

Dow-Key Microwave Corp., 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (805) 650-1734, Internet: www.dowkey.com.

Designers Can Specify Device Parameters

INTEGRATED NETWORK DEVICE MODELS have been successfully integrated into a single kernal engine that fully supports mixed-signal and mixed-rate SoC design and simulation. Device models include scattering parameters (s-parameters), admittance parameters, impedance parameters, as well as hybrid-h and hybrid-g parameters. SystemView's proprietary unified system solver automatically generates the proper timing information for all analog/digital interfaces within the system. Designers specify device parameters in SystemView using the industry-standard Touchstone® file format. SystemView's graphical interface displays individual network parameter data in tabular and graphical form. Designers can also observe the input/output reflection, reverse/forward gain/loss in real time through SystemView's interface. Network-parameter data is displayed while the device is being defined, providing the design engineer complete control of the simulation. Designers can analyze, modify, and update parameters within the same working environment.

Elanix, Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362; (800) 535-2649, FAX: (818) 597-1427, e-mail: elanix@elanix.com, Internet: www.elanix.com.

TCXO Offers OCXO Stability

THE ZT5050 SERIES temperature-controlled crystal oscillator (TCXO) offers stability as low as ±4 × 10–8 and operating temperature range can be specified as wide as –40 to +85°C. With current consumption lower than 50 mA, the ZT5050 is suitable for applications demanding both high stability and low power loading. The ZT5050 features a compact package and is available from 10 to 60 MHz, with either +3.3- or +5.0-VDC supply voltage. The ZT5050 is available in small quantities, and specification can be customized to exact requirements.

Greenway Industries, Inc., 840 West Church Rd., Mechanicsburg, PA 17055; (717) 766-0223, FAX: (717) 790-9509, e-mail: sales@greenwayindustries.com, Internet: www.greenrayindustries.com.

Bandpass Filter Features Attenuation Out To 19 GHz

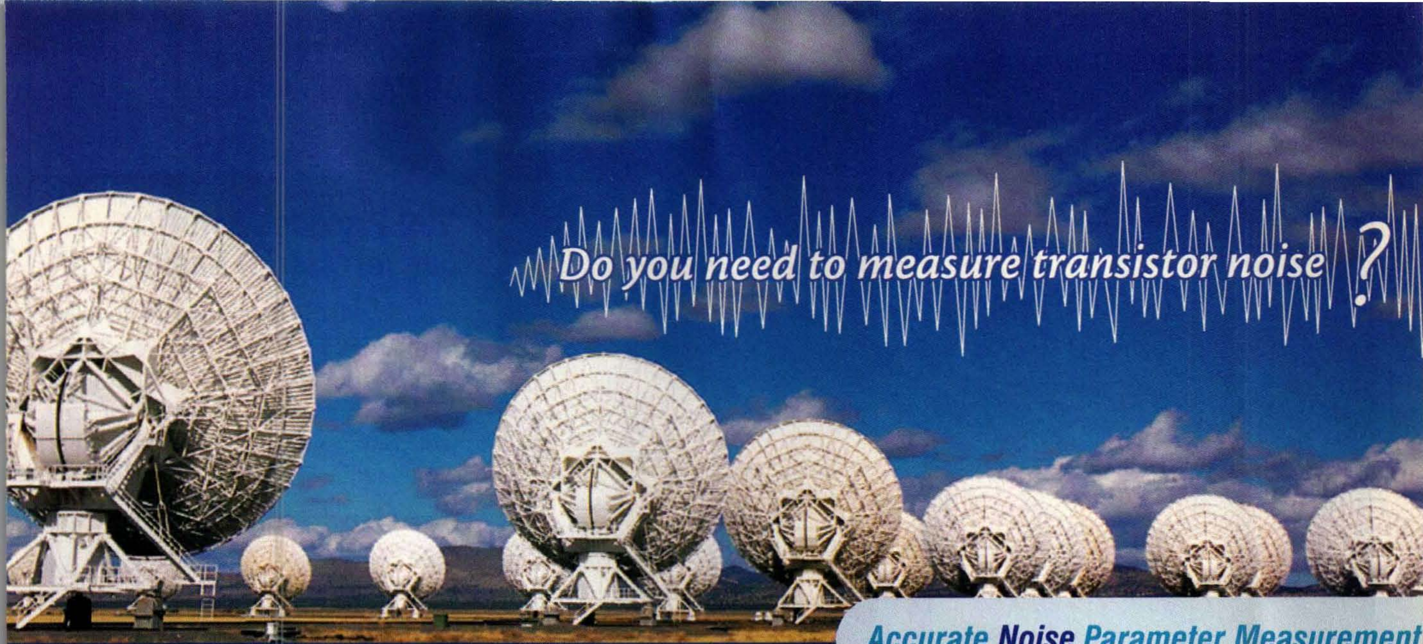
THE 9SB10-7000/T4000-O/O is a bandpass filter that features an ultimate attenuation out to 19 GHz. The package size is 2.0 × 1.0 × 0.5 in. (5.08 × 2.54 × 1.27 cm) with SMA connectors. The 9SB10-7000/T400-O/O, a 5-to-9-GHz bandpass unit, offers 2.0:1 VSWR across the passband and <1.0-dB insertion loss at center frequency. Stopbands are <50 dB at DC to 4 GHz and <50 at 10 to GHz. It contains group-delay variation: <1.5 ns over any 1 GHz within the 5-to-9-GHz passband. Contact the company for pricing in specific quantities.

K&L Microwave, Inc., 2250 Northwood Dr., Salisbury, MD 21801; (410) 749-2424, Internet: www.klmicrowave.com.

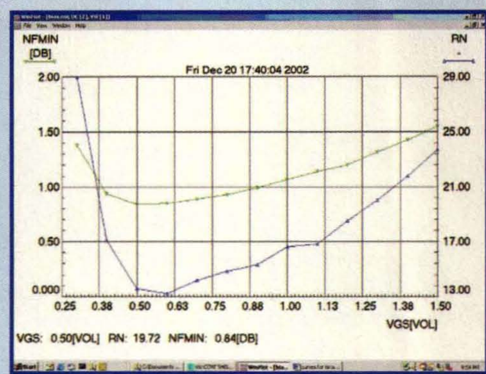
Ceramic Filter Is Used In WLAN Applications

THE 311-00036 CERAMIC FILTER is used in wireless 802.11x local-area-network (LAN) applications, including Wi-Fi, Network Interface Cards (NIC), and Access Points (AP). With a center frequency at 5800 MHz, the low-profile model 311-00036 offers bandwidth at ±50 MHz, insertion loss at 3 dB maximum, return loss at 10 dB minimum, and ripple at 1 dB maximum. This rugged, monoblock three-pole filter has dimensions at 14 × 3 mm and is available in surface-mount tape and reel. Custom designs are available in 802.11x frequency band.

TRAK Microwave Corp., 4726 Eisenhower Blvd., Tampa, FL 33634-6391; (813) 901-7200, FAX: (813) 901-7491, e-mail: tmc@trak.com, Internet: www.trak.com.

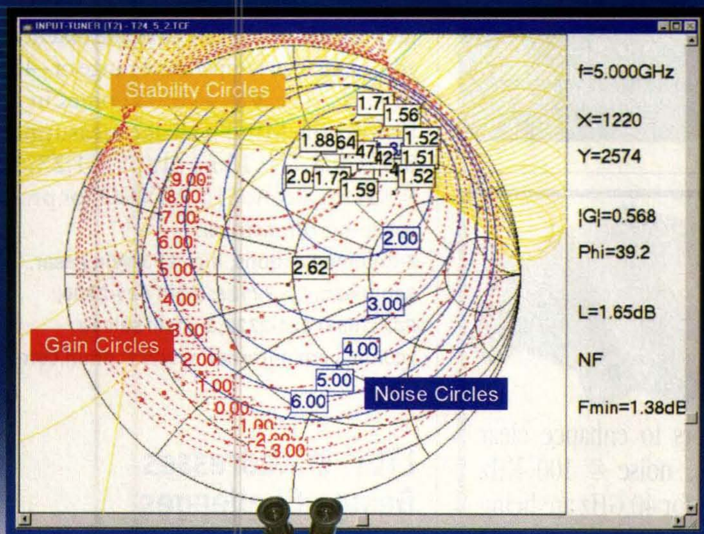


*Accurate **Noise** Parameter Measurement*



Critical customers have experienced the truth:

"ELECTROMECHANICAL TUNERS ARE THE BEST SOLUTION FOR TRUE AND ACCURATE NOISE PARAMETER MEASUREMENTS."



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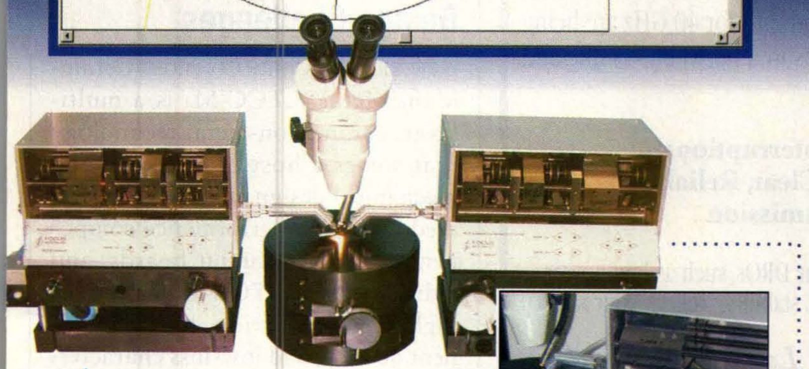
- "Hot/Cold" noise source impedance correction
- Chip-pad noise parameter de-embedding
- Supports Agilent 8970, 8973, 8975 NFM
- Supports spectrum analyzers as single sideband noise receivers
- Tuners and Noise receiver calibrated in-situ
- 0.2 - 65 GHz coaxial, 26.5 - 110 GHz waveguide



New Ultra-Stable dedicated tuner probe station

Talk to the Experts ...

Focus microwaves

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Email: info@focus-microwaves.com
Web: www.focus-microwaves.com

* *Using existing probe stations or as part of the new Focus on-wafer tuner system*

VCO Provides Solution For Terrestrial Radio

THE V844ME05 IS A voltage-controlled oscillator (VCO) for the terrestrial-radio market that covers 3970 to 4150 MHz within +0.5 to +4.5 VDC of control voltage while covering 180-MHz bandwidth with an average tuning sensitivity of 70 MHz/V. The V844ME05 draws 18 mA off of a +5-VDC supply and furnishes the end user with 225±1.25 dBm of output power into a 50-Ω load, guaranteed to operate over the extended commercial temperature range of –40 to 85°C. The V844ME05 comes in a low-profile MINI package measuring 0.5 × 0.5 × 0.13 in. (1.27 × 1.27 × 0.33 cm). P&A: $15.95/VCO for prototyping quantities.

Z-Communications, Inc., 9939 Via Pasar, San Diego, CA 92126; (858) 621-2700, FAX: (858) 621-2722, e-mail: sales@zcomm.com, Internet: www.zcomm.com.

LTCC-M Addresses Design Challenges

LOW TEMPERATURE CO-FIRED Ceramic on Metal (LTCC-M) is a multilayer, ceramic-on-metal technology that solves a host of electrical and mechanical design challenges associated with high-performance components, modules, circuit boards, and hybrid systems. LTCC-M delivers the high heat dissipation, high component density, and low-loss characteristics necessary to satisfy the demands of next-generation components and modules with increased bandwidth and functionality. Examples of these products include high-power microwave devices, fiber-optic communications systems, automotive electronic systems, and military/aerospace platforms. To

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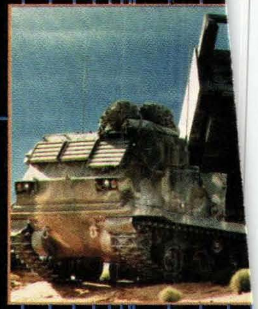
QEAM™

(Quick Erecting Antenna Mast)

Field Deployable Antenna Feeder Cables

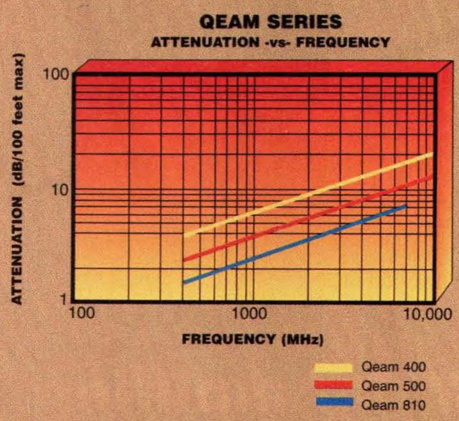


Whether for mission critical military applications or for commercial use, field deployable antenna feeder cables need to be rugged enough to withstand the rigors of repeated reelings, while providing good electrical performance and resistance to a variety of harsh environments. QEAM cable, field proven on the Hawk and Patriot Missile launch systems, is the only cable that meets all these demands.

QEAM antenna feeder cables use an expanded PTFE dielectric, flexible conductors and durable jackets to achieve low bending moment flex life in excess of 10,000 bends on properly selected radii.

Based on the proven designs of Times Microwave Systems' MILTECH aerospace cable assemblies, QEAM assemblies are:

- Completely weather sealed
- Built to MIL-T-81490 requirements
- Corrosion resistant, using heavy duty stainless steel connectors
- Fully tested over specified frequency bands



QEAM cables are supplied as finished assemblies and may be fitted with hoisting grips and customized to specific military or commercial application requirements.

For rugged field deployable use, where reeling and unreeling durability are required over a wide temperature range, specify the ultimate antenna feeder cable — specify QEAM.

Keep up to date on our latest developments, look for additional Tech Center releases.

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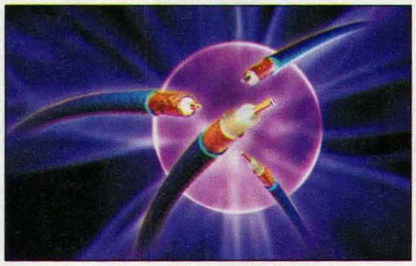
Lamina Ceramics, Inc., 120 Hancock Lane, Westampton, NJ 08060; (800) 808-5822, FAX: (609) 265-9905, e-mail: info@laminaceramics.com, Internet: www.laminaceramics.com.

Flexible Cable Series Saves Time And Money

THE SM SERIES CABLE is a highly flexible product for use in applications from DC to 18 GHz. The flexibility of SM Series cable allows designers to bypass the cumbersome and



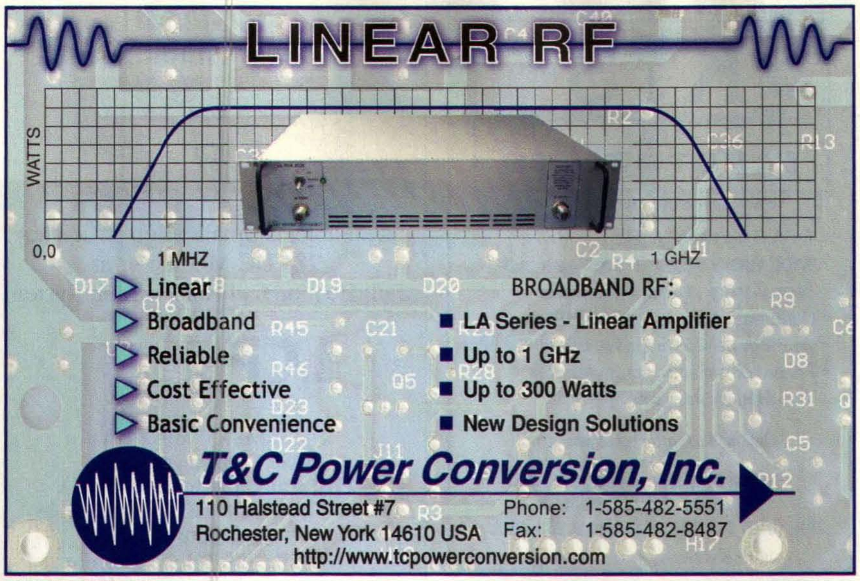
costly step of fabricating three-dimensional (3D) semi-rigid drawings, resulting in cost savings and faster time to market. The outer-shield construction of the SM Series cable consists of a braided layer over a served foil, providing >100 dB of shielding. The operating temperature range is –65 to +125°C. The SM402 is for use with 0.141-in. semi-rigid connectors. The SM405 is for use with 0.086-in. semi-rigid connectors. P&A: From \$2.36/ft. to \$1.03/ft. depending on quantity. SM Series cable is stocked and available for immediate delivery on bulk reels.

Semflex, Inc., 5550 East McDowell Rd., Mesa, AZ 85212; (800) 778-4401, Internet: www.semflex.com.

Synthesizers Work Over A Wide Temperature Range

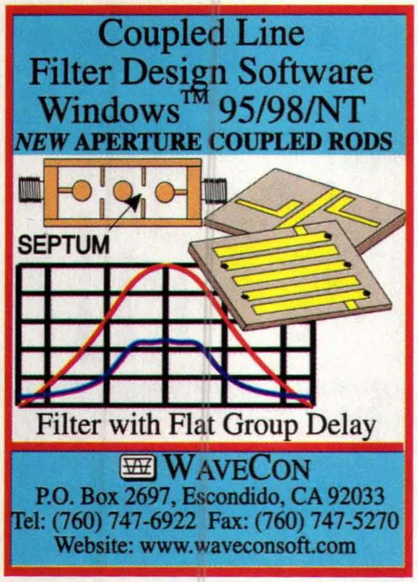
MFS COMPACT DEVICES EMPLOY a single module design implemented with complementary metal-oxide semiconductor (CMOS), application-specific integrated circuits (ASICs), advanced monolithic microwave integrated circuits (MMICs), and a dedicated microprocessor. A C-band synthesizer operates with bandwidths to 1.2 GHz and 1- or 125-kHz steps. The synthesizers meet the needs of military requirements as well as IESS 308, Eutelsat, and MIL-STD188-146.

Elcom Technologies, Inc., 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030 ext. 230, FAX: (201) 767-0542, e-mail: sales@elcom-tech.com, Internet: www.elcom-tech.com.



T&C POWER CONVERSION

WIDE BAND ENGINEERING



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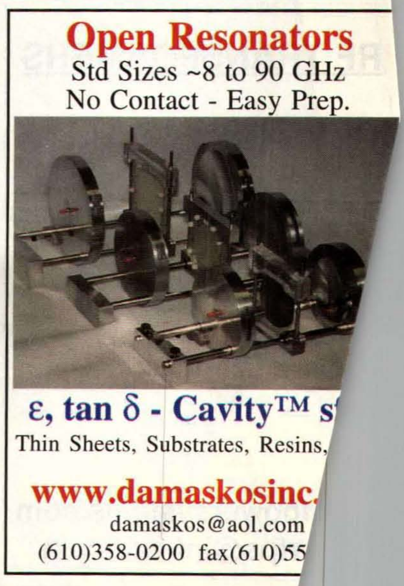

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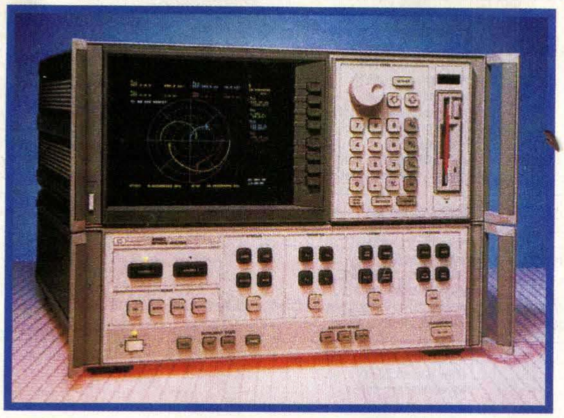
looking back



JUST OVER A dozen years ago, enhancements to the HP 8510C from Hewlett-Packard Co. (now Agilent Technologies, Santa Rosa, CA) brought the coaxial VNA to 50 GHz with improved accuracy and speed.

next month

Microwaves & RF March Editorial Preview

Issue Theme: Semiconductors

News

Advances in semiconductor technology have yielded great strides in RF and microwave performance over the last decade. But these process and materials advances have also meant drastic improvements in many of the analog and digital circuits commonly used by RF engineers, including ADCs, DACs, and DSPs. This Special Report in March will survey some of the recent advances in these analog/digital circuits, especially for high-speed (100 MHz and faster) devices of particular interest to designers of commercial and military systems and test equipment.

Design Features

Design Features in March will focus on semiconductor technologies and their applications in a variety of wireless systems, including the use of low-cost UHF ICs for monitoring the air pressure of vehicle tires and a comparison of high-frequency control devices (such as switches) based on a variety of semiconductor processes, including GaAs, InP, and GaN. Technical articles will also explore measurement methods for checking the performance of high-power amplifiers with the burst waveforms commonly found in many modern communications systems, and techniques for constructing gain-slope equalizers for millimeter-wave amplifiers.

Product Technology

The March Product Technology section will highlight a line of full-featured signal analyzers about the size of a small laptop computer. Although compact, these portable analyzers provide the wide frequency ranges and dynamic ranges needed for the most critical military applications. Additional product features in March will cover a line of power combiners/dividers for applications to 3 GHz, a set of low-cost broadband amplifiers for 40-Gb/s OC-768 applications, a novel analog circuit that improves the distortion (dynamic-range) characteristics of PAs, and a unique millimeter-wave Grid amplifier technology capable of achieving tube-like power from semiconductor amplifiers.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Miniature
Variable Attenuators
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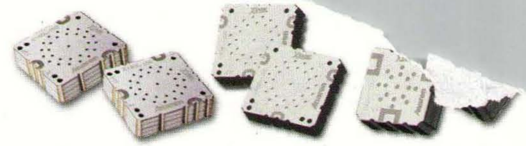


The world's first true SM circulator is now its first true SM circulator family!

In 2002, we introduced the first-ever "no touch," surface mount circulator in our popular Xinger®-brand package. Next came a model 1/4 the size. Next came our 800 and 900 MHz models.

In other words, we now have a full (and still growing, aggressively priced!) line-up of revolutionary, surface mounted circulators. Choose from these models, all more competitively priced than ever:

- 800 and 900 MHz models measuring 1.0 x 1.0 x 0.287" (25.4 x 25.4 x 7.29 mm)
- Quarter-size 1.8, 1.9, 2.1 GHz units measuring 0.5 x 0.5 x 0.163" (12.7 x 12.7 x 4.14 mm)
- Original 1.8, 1.9, 2.1 GHz units measuring 1.0 x 1.0 x 0.287" (25.4 x 25.4 x 7.29 mm)

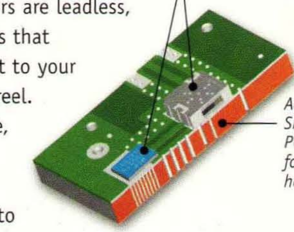
They're standard circulators in Xinger clothing!

We even bring you a matched termination.

To convert your surface mounted Xinger-brand circulator to an isolator, add one of our perfectly matched RF Power-brand, AlN-ceramic SM terminations to your design – with power-handling up to 100 Watts when mounted on the PCB with our ideal, Smart Backing PCB technology as a heat sink solution.

Direct-mounting to your PCB is just the beginning.

Circulator & termination direct-mount to PCB.

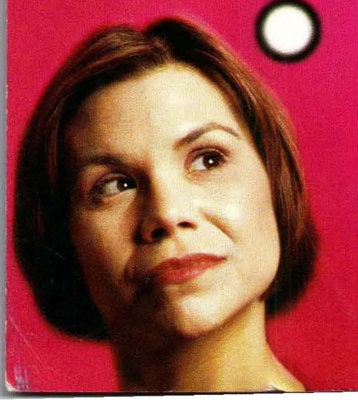


Add our new Smart Backing™ PCB technology for superior heat dissipation.

Xinger-brand circulators are leadless, multilayer components that precision-mount direct to your PCB from a tape and reel. Add industry-exclusive, Smart Backing PCB technology from our Anaren Europe group to elegantly handle heat-dissipation. Incorporate a Xinger-brand directional coupler with our 1" square component for power detection... and you have a totally no-touch assembly output stage!

Call today for your free, Xinger-brand circulator kit!

To begin cutting production times and boosting performance with our circulator line – call 800-SMCIRCULATE or email us at smcirculate@anaren.com And see why excitement about our Xinger-brand circulator family is mounting!



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